

Savina

Intensive Care Ventilator

Operating Instructions
Software 2.1n





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How to Work With These Operating Instructions

The header line...

contains the main chapter title

to help you quickly find your way around in the manual.

The page body...

contains the instructions for use

in a combination of text and illustrations. The information is expressed directly in terms of actions, enabling users to familiarize themselves with the operation of the ventilator by hands-on activities.

The left-hand column...

contains text

which provides explanations and guides the user with brief and clear instructions in an ergonomic sequence for confusion free use of the ventilator.

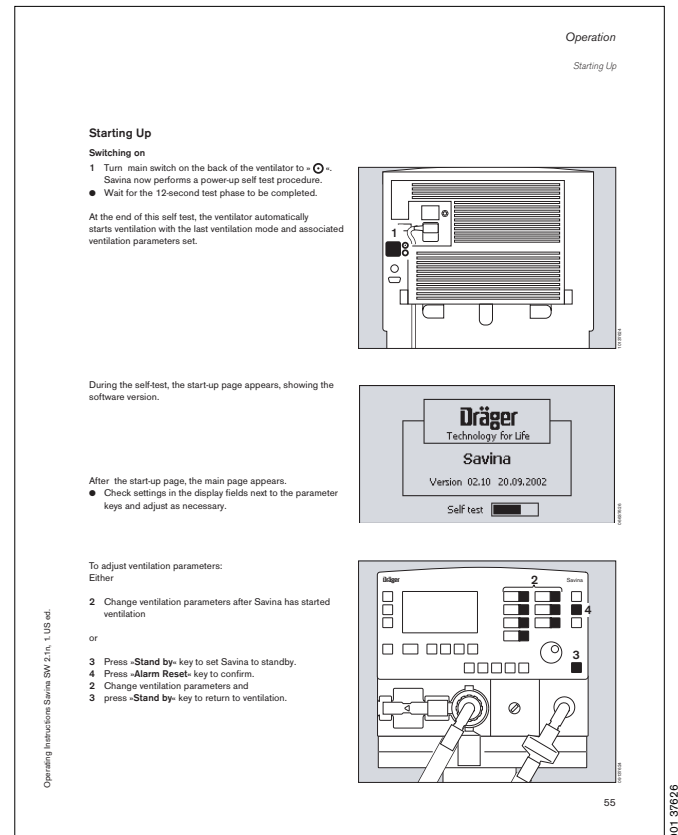
Bullet points indicate steps of actions. In many cases, numbers are used to highlight the relation between the step described in the sequence of operations and the associated illustration(s).

The right-hand column...

contains illustration(s)

relating directly to the facing text column and shows users where to find the elements mentioned in the text. Non-essentials are omitted.

Renderings of ventilator screen images guide the user and allow to reconfirm steps of actions to be performed.



WARNING !

Strictly follow this Operator's Instruction Manual.

Any use of the product requires full understanding and strict observation of all portions of these instructions. The equipment is only to be used for the purpose specified under "Intended Use" on page 20 and in conjunction with appropriate airway monitoring (see page 22). Observe all WARNINGS and CAUTIONS as rendered throughout this manual and on labels on the equipment.

Installed Options

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Important Safety Information READ THIS FIRST!

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Important Safety Information

Operator's Responsibility for Patient Safety

WARNING !

Strictly follow this Operator's Instruction Manual
Any use of the product requires full understanding and strict observation of all portions of these instructions. The equipment is only to be used for the purpose specified under "Intended Use" on page 20 and in conjunction with appropriate airway monitoring (see page 22). Observe all WARNINGS and CAUTIONS as rendered throughout this manual and on labels on the equipment.

The design of the equipment, the accompanying literature, and the labeling on the equipment take into consideration that the purchase and use of the equipment are restricted to trained professionals, and that certain inherent characteristics of the equipment are known to the trained operator. Instructions, warnings, and caution statements are limited, therefore, largely to the specifics of the Draeger design.

This publication excludes references to various hazards which are obvious to a medical professional and operator of this equipment, to the consequences of product misuse, and to potentially adverse effects in patients with abnormal conditions. Product modification or misuse can be dangerous. Draeger Medical, Inc. disclaims all liability for the consequences of product alterations or modifications, as well as for the consequences which might result from the combination of this product with other products whether supplied by Draeger or by other manufacturers if such a combination is not endorsed by Draeger Medical, Inc.

Patient monitoring

The operators of the ventilator system must recognize their responsibility for choosing appropriate safety monitoring that supplies adequate information on equipment performance and patient condition. Patient safety may be achieved through a wide variety of different means ranging from electronic surveillance of equipment performance and patient condition to simple, direct observation of clinical signs.

The responsibility for the selection of the best level of patient monitoring lies solely with the equipment operator.

Limitation of Liability

Draeger Medical, Inc.'s liability, whether arising out of or related to manufacture and sale of the goods, their installation, demonstration, sales representation, use, performance, or otherwise, including any liability based upon Draeger Medical, Inc.'s Product Warranty, is subject to and limited to the exclusive terms and conditions as set forth, whether based upon breach of warranty or any other cause of action whatsoever, regardless of any fault attributable to Draeger Medical, Inc. and regardless of the form of action (including, without limitation, breach of warranty, negligence, strict liability, or otherwise).

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Draeger Medical, Inc. shall not be liable for, nor shall buyer be entitled to recover any special incidental, or consequential damages or for any liability incurred by buyer to any third party in any way arising out of or relating to the goods.

Warranty

All Draeger products are guaranteed to be free of defects for a period of one year from date of delivery.

The following are exceptions to this warranty:

1. The defect shall be a result of workmanship or material. Defects caused by misuse, mishandling, tampering, or by modifications not authorized by Draeger Medical, Inc. or its representatives are not covered.
2. Rubber and plastic components and materials are warranted to be free of defects at time of delivery.

Any product which proves to be defective in workmanship or material will be replaced, credited, or repaired with Draeger Medical, Inc. holding the option. Draeger Medical, Inc. is not responsible for deterioration, wear, or abuse. In any case, Draeger Medical, Inc. will not be liable beyond the original selling price.

Application of this warranty is subject to the following conditions:

1. Draeger Medical, Inc. or its authorized representative must be promptly notified, in writing, upon detection of the defective material or equipment.
2. Defective material or equipment must be returned, shipping prepaid, to Draeger or its authorized representative.
3. Examination by Draeger or its authorized representative must confirm that the defect is covered by the terms of this warranty.
4. Notification in writing, of defective material or equipment must be received by Draeger or its authorized representative no later than two (2) weeks following expiration of this warranty.

The above is the sole warranty provided by Draeger Medical, Inc. No other warranty expressed or implied is intended. Representatives of Draeger are not authorized to modify the terms of this warranty.

Draeger Medical, Inc., Telford, PA

Definitions

WARNING !

A **WARNING** statement refers to conditions with a possibility of personal injury if disregarded.

CAUTION !

A **CAUTION** statement designates the possibility of damage to equipment if disregarded.

NOTE: A **NOTE** provides additional information intended to avoid inconveniences during operation.

Inspection	examination of actual condition
Service	measures to maintain specified condition
Repair	measures to restore specified condition
Maintenance	inspection, service, and repair, where necessary
Preventive Maintenance	maintenance measures at regular intervals

Typing conventions in this manual

Display messages are printed in bold, e. g:

!!! Fail to cycle

Screen keys and other controls are indicated as »**Control**«, e.g:

»**Standby**«

Abbreviations and Symbols

Please refer to “Abbreviations” on page 128 and “Symbols” on page 130 for explanations.

Labels on the equipment

Please refer to “Labels” on page 127.

Summary of WARNINGS and CAUTIONS

General Precautions

WARNING !

Strictly follow this Operator's Instruction Manual
Any use of the product requires full understanding and strict observation of all portions of these instructions. The equipment is only to be used for the purpose specified under "Intended Use" on page 20 and in conjunction with appropriate airway monitoring (see page 22). Observe all WARNINGS and CAUTIONS as rendered throughout this manual and on labels on the equipment.

WARNING !

The Savina ventilator must only be used under the supervision of qualified medical personnel in order to provide immediate corrective action in case of a malfunction.

WARNING !

In order to avoid fire hazards from elevated oxygen concentrations, always ensure a clearance of at least 4 inches (10 cm) between the back panel of the ventilator and any large obstacle or room wall.

WARNING !

This device is to be used only in rooms with line power installations complying with national safety standards for hospital patient rooms. (e.g., IEC 601.1, "Safety of Medical Equipment).
To maintain grounding integrity, connect only to a "hospital grade" receptacle. Always disconnect supply before servicing.

WARNING !

DANGER, risk of explosion if used in the presence of flammable gases or anesthetics.
This device is neither approved nor certified for use in areas where combustible or explosive gas mixtures are likely.

WARNING !

Do not use mobile phones within 33 feet (10 m) of the ventilator.
Mobile phones can cause interference with electrical and electronic medical equipment with the risk of patient injury.

WARNING !

Do not use in conjunction with nuclear spin tomography (MRT, NMR, or NMI)!
Equipment malfunction with the risk of patient injury may result.

WARNING !

Using high frequency electrosurgery equipment, defibrillators, or short-wave treatment equipment in the vicinity of the ventilator may interfere with its operation and pose a risk of patient injury.

WARNING !

Do not use the Savina ventilator in hyperbaric chambers.
Equipment malfunction may result, with the risk of patient injury.

WARNING !

Avoid pollutants in the ambient air.
Savina uses ambient air for ventilation and pollutants would enter the patient's airways.

WARNING !

Do not place the Savina ventilator on a patient's bed while in motion.
Ensure that the ventilator is properly secured to prevent it from falling or being knocked over.

WARNING !

To avoid risk of ventilator failure, always protect Savina from splashes and rain. The ventilator is not designed to be splash-proof.

WARNING !

In case of malfunction of any of the built-in monitoring, a substitute must be provided in order to maintain an adequate level of monitoring. The operator of the ventilator system must still assume full responsibility for proper ventilation and patient safety in all situations.

WARNING !

Back-up ventilation with an independent manual ventilation device

If a fault is detected in the Savina ventilator, so that its life-support functions are no longer assured:

- start ventilation using an independent ventilation device (resuscitation bag) without delay, if necessary with PEEP and / or increased inspiratory O₂ concentration.

CAUTION !

Restriction of Distribution

Federal Law and Regulations in the United States and Canada restrict this device to sale by or on the order of a physician.

Device for use in health care facilities only and exclusively by persons with specific training and experience in its use.

CAUTION !

While ventilator is exposed to transport conditions, e.g. in an aircraft, vibration of patient circuits may affect flow measurement.

Precautions during preparation

WARNING!

Do not place containers of liquids (such as infusion bottles) on top of or above the Savina ventilator. Liquids getting into the ventilator can cause equipment malfunction with the risk of patient injury.

WARNING!

Always use components that have been properly cleaned and disinfected.

WARNING !

Never operate Savina without a water trap on the expiratory valve - overcompensation for leakage might cause unintentionally high airway pressure and false triggering might occur.

WARNING!

Always use a bacteria filter on the inspiratory port of the ventilator in order to protect the patient from contaminants in the ambient air drawn for ventilation.

WARNING!

Draeger cannot warrant or endorse the safe performance of heat/moisture exchangers with the Savina ventilator. The user has to verify that the heat/moisture exchanger is covered by a technical safety certificate which guarantees its complete suitability for its intended use.

Do not use a heat/moisture exchanger simultaneously with a nebulizer or heated humidifier!

Risk of increased breathing resistance due to condensation.

WARNING!

The flow resistance of bacteria filters placed in the expiratory side may be substantially increased by nebulized aerosols with the risk of impaired ventilation. If an expiratory filter is used during nebulization, airway pressures and flow should be monitored for any indication of increased expiratory resistance due to filter obstruction.

WARNING!

The inspiratory breathing gas is warmed by the built-in blower for the ventilator. For appropriate cooling of the breathing gas it is therefore mandatory to use a patient circuit with a total length of no less than 1.2 m (4 feet). If shorter circuits would be used, the breathing gas temperature at the patient wye might exceed the permissible limit with the risk of patient injury.

WARNING!

Draeger cannot warrant or endorse the safe performance of third party humidifiers for use with the Savina ventilator. Specifically, the user has to assess the risks of delivery of breathing gas not maintained at a proper temperature associated with different humidifier designs. It is strongly recommended to use the electronic temperature monitoring feature of the ventilator if no proximal airway temperature monitoring is performed by the humidifier used.

Increased pneumatic resistance in the inspiratory line caused by a humidifier may result in less accurate airway pressure readings.

We recommend contacting the manufacturers/ distributors of third party humidifier devices about compliance of their products with the requested performance characteristics.

WARNING!

Do not use a heat/moisture exchanger (HME) simultaneously with a heated humidifier!

Risk of increased breathing resistance due to condensation.

WARNING!

In order to avoid any risk of electric shock in the event of faulty grounding of patient monitoring equipment, do not use antistatic or electrically conductive patient circuits.

WARNING!

Do not use inspiratory circuits with a total length of less than 1.2 m (4 feet) between humidifier and wye. Otherwise risk of excessive breathing gas temperatures!

WARNING !

Do not use humidifiers without temperature regulation. Otherwise risk of excessive breathing gas temperature!

WARNING !

This device is to be used only in rooms with line power installations complying with national safety standards for hospital patient rooms. (e.g., IEC 601.1, "Safety of Medical Equipment).

To maintain grounding integrity, connect only to a "hospital grade" receptacle. Always disconnect supply before servicing.

WARNING !

Connecting other devices to the same extension power strip may, in the event of grounding failure, cause the leakage current to the patient to increase beyond the permissible values.

In this case, the risk of electric shock cannot be safely excluded.

WARNING !

Use rechargeable batteries ONLY.

Because of the charging feature of the Savina DC power supply, connecting non-rechargeable batteries might lead to a risk of explosion when operating the ventilator from line power.

WARNING !

Always use medical grade oxygen that is dry and free from contaminations. Contaminated gas may cause ventilator malfunction.

Ensure a reliable source of 100% oxygen. Brief fluctuations in the concentration may lead to an incorrect calibration of the O2 sensor.

WARNING !

The ventilator is ready for operation only when:

- it is completely assembled with all required auxiliary equipment in place,
- all sensors are calibrated (O2, Flow),
- all tests of readiness for operation have been completed successfully.

WARNING !

- Installation of the Savina nurse call kit should only be performed by DraegerService or factory trained and authorized service personnel.

WARNING !

The operator of the ventilator must still assume full responsibility for ventilation monitoring via the Savina screen when the nurse call is connected.

Only warning messages (!!!), i. e. alarm messages with top priority, will activate the nurse call.

- Regularly check on-screen messages.

WARNING !

A fault within any component of the combination between the nurse call and the central alarm system of the hospital (e. g. inside the Savina nurse call electronics, the Savina power supply, or the hospital alarm equipment) may result in a failure of a proper nurse call function.

WARNING !

Do not use ventilator if the tests are not completed successfully.

CAUTION !

Do not connect AC/DC power supplies to the DC input.

Precautions regarding electrical supplies

WARNING !

Leave Savina connected to AC line power only in well ventilated rooms (minimum air circulation: 1.2 m³/h). Charging batteries generates hydrogen, that, with sufficient concentration, could cause an explosion with the risk of personal injury.

WARNING !

An uneven discharge gradient indicates that the battery is insufficiently charged or defective. In this case, the remaining capacity can be expected to be zero at any moment.

WARNING !

If the WARNING "!!! Int. batt. almost discharged" appears, Savina could stop working at any moment. Immediately reconnect Savina to AC line power, a charged external battery, or DC on-board system in order to prevent any interruption of ventilation.

CAUTION !

Discharging the internal battery repeatedly without a full recharge in between may damage the battery

Precautions during operation

WARNING !

Always use ventilator that has been cleaned and disinfected and has been successfully tested to be ready for operation.

WARNING !

In case of a fault in any of the built-in monitoring a substitute has to be provided in order to maintain an adequate level of monitoring. The operator of the ventilator must still assume full responsibility for proper ventilation and patient safety in all situations.

WARNING !

If a fault is detected in the ventilator and its life-support functions are in doubt, ventilation must be started without delay with an independent ventilation device (resuscitation bag) - using PEEP and/or increased inspiratory O₂ concentration where necessary and appropriate. The unit should then be removed from use and serviced by an authorized service technician.

WARNING !

- Always use extreme caution when using oxygen!
- Oxygen intensely supports any burning!
No smoking, no open fire in areas where oxygen is in use!
- Always provide adequate ventilation in order to maintain ambient O₂ concentrations < 24 %.
- Always secure O₂ cylinders against tipping, do not expose to extreme heat.
- Do not use oil or grease on O₂ equipment such as tank valves or pressure regulators.
Do not touch with oily hands. Risk of fire!
- Open and close valves slowly, with smooth turns.
Do not use any tools.

WARNING !

Always heed all precautions and follow all hospital protocols with respect to the administration of oxygen. Make adjustments to the FiO₂ according to the blood gas values measured.

WARNING !

Do not block air intake. Ventilator malfunction will result.

WARNING!

Do not place containers of liquids (such as infusion bottles) on top of or above the Savina ventilator. Liquids getting into the ventilator can cause equipment malfunction with the risk of patient injury.

WARNING !

Warning or Caution level audible alarms require immediate operator attention to avert or to prevent development of situations with the possibility of patient injury.

WARNING !

The alarm silence key is intended to provide a way of muting audible alarms while corrective action is taken. The operator of the ventilator must still assume responsibility for proper ventilation and patient safety in the event of an alarm. Failure to identify and correct alarm situations may result in patient injury.

WARNING !

Installation of the Savina NIV option should only be performed by DraegerService or factory trained and authorized service personnel.

WARNING !

Precautions when using mask ventilation.

- Never ventilate an intubated patient in »Mask/NIV« mode
- In MASK/NIV« mode, the alarm system is adapted to mask ventilation. Make sure that only patients are ventilated in this mode who can breathe sufficiently on their own, especially when alarms have been manually disabled.
- When masks are used, dead space increases.
- Always follow the mask manufacturer's directions to properly deal with the increased dead space caused by the mask.
- Avoid high airway pressures. Risk of aspiration.
- Never operate Savina without a water trap on the expiratory valve - overcompensation for leakage might cause unintentionally high airway pressure and mis-triggering might occur.
- Always check alarm limits after changing from »Mask/NIV «to »Tube« mode.

WARNING !

Never operate Savina without a water trap on the expiratory valve - overcompensation for leakage might cause unintentionally high airway pressure and false triggering might occur.

WARNING !

Only switch off alarms if the safety of the patient will not be compromised by the absence of an alarm. The operator of the ventilator system must still assume full responsibility for proper ventilation and patient safety in all situations.

WARNING !

Always check alarm limits after changing from »Mask/NIV «to »Tube« mode.

WARNING !

Never use flammable medications (e.g. on the basis of ethanol). Fire hazard!

WARNING !

Since Savina uses pure oxygen for nebulizing pharmaceutical aerosols, an increase of the set inspiratory O₂ concentration may result.

WARNING !

The integrated nebulizer function of Savina is designed for nebulizers with a nebulizing flow of 6 L/min at 29 psi (2 bar), for example nebulizer 84 12 935 (white central body). Use of other pneumatic nebulizers may result in considerable discrepancies in the minute-volume reading!

WARNING !

Do not use a heat/moisture exchanger (HME) while nebulizing pharmaceutical aerosols. Risk of increased breathing resistance.

WARNING !

Consider effects of aerosols on sensors and filters!
The measuring function of the flow sensor may be impaired.
The flow resistance of filters is liable to increase and may impair ventilation.
Do not put a bacteria filter on the nebulizer outlet when in use!

WARNING !

Always pay special attention to the success of a flow calibration. The operator of the ventilator must still assume responsibility for proper ventilation and patient safety in the event of a loss of expiratory flow monitoring. Replace a faulty flow sensor as soon as possible.

WARNING !

Always use a reliable independent O₂ supply during calibration that contains 100% O₂. In case the calibration procedure is based on a diluted oxygen source, Savina may deliver inaccurate oxygen concentrations without further notification.

WARNING !

In the event of a failure of the turbine blower, Savina is not able to continue ventilation. Immediately continue ventilation using an independent manual ventilation device (resuscitation bag) in this case.

Precautions during configuration

WARNING !

Always adjust audible alarm volume to a level that ensures the operator will be alerted when alarms occur. Failure to identify and correct alarm situations may result in patient injury.

WARNING !

Always use a reliable independent O₂ source during calibration that supplies 100% O₂. In case the calibration procedure is based on a diluted oxygen source, Savina may deliver inaccurate oxygen concentrations without further notification.

WARNING !

In case of a fault in any of the built-in monitoring a substitute has to be provided in order to maintain an adequate level of monitoring. The operator of the ventilator must still assume full responsibility for proper ventilation and patient safety in all situations.

Precautions during care procedures

WARNING !

To avoid risks to hospital staff and patients, disinfect and clean ventilator after use.
Always use ventilator that has been cleaned and disinfected and has been successfully tested to be ready for operation.

WARNING !

Always follow accepted hospital procedures for handling equipment contaminated with body fluids.

WARNING !

Sterilization of parts in ethylene oxide (EtO) may lead to a patient health risk:
Patients may become exposed to EtO that may have diffused into components.

WARNING !

To avoid any risk of infection for hospital staff or other patients, clean and disinfect ventilator after use.
Follow all accepted hospital procedures for disinfecting parts contaminated by body fluids (protective clothing, eyewear, etc.).

WARNING !

Vent flow sensor after disinfection with ethanol for at least 30 minutes or rinse with sterile water. Otherwise, residual ethanol vapors might ignite and destroy the sensor during calibration.

CAUTION !

When removing a reusable patient circuit, always grasp hoses by their sleeve, never by the hose itself, to avoid possibly tearing the hose at the sleeve or ripping it out of the sleeve.

CAUTION !

Flow sensor is not compatible with parts washer equipment and may not be autoclaved or steam-sterilized. It cannot withstand high temperatures and would be destroyed.

CAUTION !

Do not disassemble expiratory valve beyond removing diaphragm!

CAUTION !

Certain components of the ventilator consist of materials that are sensitive to certain organic solvents sometimes used for cleaning and disinfecting (e.g., alkylamines, phenols, halogen releasing compounds, oxygen releasing compounds, strong organic acids, etc.). Exposure to such substances may cause damage that is not always immediately recognized.

Precautions during maintenance

WARNING !

To avoid any risk of infection, clean and disinfect ventilator and accessories before any maintenance according to established hospital procedures - this applies also when returning ventilators or parts for repair.

WARNING !

Never operate the ventilator if it has suffered physical damage or does not seem to operate properly. We recommend that you contact DraegerService for maintenance service for the Savina Ventilator.

WARNING !

Treatment of batteries and O₂-sensor capsules:
Do not throw into fire! Risk of explosion.
Do not force open! Danger of bodily injury.
Follow all local, state, and federal regulations with respect to environmental protection when disposing of batteries and O₂-sensor capsules.

WARNING !

Both breathing and cooling air are drawn in through the filter cover.
Do not block air intake, do not place ventilator immediately against a wall – risk of overheating the ventilator.

WARNING !

When servicing the ventilator, always use replacement parts that are qualified to Draeger standards. Draeger cannot warrant or endorse the safe performance of third party replacement parts for use with the Savina ventilator.

CAUTION !

Never operate the ventilator without a microfilter at the air intake. The inspiratory side of the ventilator and patient circuit would become dirty.

CAUTION !

Maintenance

The device must be inspected and serviced at regular intervals. A record must be kept on this preventive maintenance. We recommend obtaining a service contract with DraegerService through your vendor. For repairs we recommend that you contact DraegerService.

CAUTION !

Avoid storing the ventilator for extended periods at temperatures over 50 °C.
The internal battery and O₂ sensors may be damaged, or equipment life may be shortened

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Intended Use

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Intended Use

Intended Medical Applications

Savina®*

Long-term ventilator for intensive care.

For patients requiring tidal volumes starting at 50 mL.

With the following ventilation modes

CMV

Continuous Mandatory Ventilation

controlled and assisted constant-volume ventilation with intermittent (IPPV) or continuous (CPPV) positive airway pressure.

With the options:

CMV_{Assist}

Assisted ventilation with continuous positive airway pressure.

IRV

Inversed Ratio Ventilation

PLV

Pressure Limited Ventilation

AutoFlow®** (optional)

While automatically optimizing inspiratory flow and minimizing airway pressure, AutoFlow permits spontaneous breathing at any time during the breathing cycle.

SIMV

Synchronized Intermittent Mandatory Ventilation

Ventilation mode for weaning patients off the ventilator after they have started breathing spontaneously.

With the options:

PLV

Pressure Limited Ventilation

AutoFlow® (optional)

While automatically optimizing inspiratory flow and minimizing airway pressure, AutoFlow permits spontaneous breathing at any time during the breathing cycle.

CPAP

Continuous Positive Airway Pressure

Spontaneous breathing with positive airway pressure.

SB

Spontaneous Breathing

PSV

Pressure Support Ventilation

Pressure-assisted spontaneous breathing.

PCV+ (optional)

Pressure Controlled Ventilation plus (BIPAP^{***})

Pressure-controlled ventilation combined with free spontaneous breathing during the whole breathing cycle, and with an adjustable pressure assist starting on CPAP level.

Special modes:

Apnea Ventilation

For automatically switching over to volume-controlled mandatory ventilation if breathing stops.

With monitoring for

- airway pressure, Paw
- expiratory minute volume, MV
- inspiratory O₂ concentration, FiO₂
- inspiratory breathing gas temperature, T
- apnea
- breath rate
- inspiratory tidal volume

Intended Areas of Use

- in the Intensive Care ward or in the recovery room
- during secondary transport from one hospital to another
- during transfer of ventilated patients within the hospital
- during transfer flights^{****}

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**** Please refer to FAA or other pertinent regulations regarding the required permits for mobile use of the Savina ventilator (in aircraft, etc.)

* Savina® is a registered trade mark of Dräger

** AutoFlow® is a registered trademark of Dräger

Restrictions of Use

CAUTION ! Restriction of Distribution

Federal Law and Regulations in the United States and Canada restrict this device to sale by or on the order of a physician.

Device for use in health care facilities only and exclusively by persons with specific training and experience in its use.

WARNING !

The Savina ventilator must only be used under the supervision of qualified medical personnel in order to provide immediate corrective action in case of a malfunction.

WARNING !

In order to avoid fire hazards from elevated oxygen concentrations, always ensure a clearance of at least 4 inches (10 cm) between the back panel of the ventilator and any large obstacle or room wall.

WARNING !

This device is to be used only in rooms with line power installations complying with national safety standards for hospital patient rooms. (e.g., IEC 601.1, "Safety of Medical Equipment).

To maintain grounding integrity, connect only to a "hospital grade" receptacle. Always disconnect supply before servicing.

WARNING !

DANGER, risk of explosion if used in the presence of flammable gases or anesthetics.

This device is neither approved nor certified for use in areas where combustible or explosive gas mixtures are likely.

WARNING !

Do not use mobile phones within 33 feet (10 m) of the ventilator.

Mobile phones can cause interference with electrical and electronic medical equipment with the risk of patient injury*

WARNING !

Do not use in conjunction with nuclear spin tomography (MRT, NMR, or NMI)!

Equipment malfunction with the risk of patient injury may result.

WARNING !

Using high frequency electrosurgery equipment, defibrillators, or short-wave treatment equipment in the vicinity of the ventilator may interfere with its operation and pose a risk of patient injury.

WARNING !

Do not use the Savina ventilator in hyperbaric chambers. Equipment malfunction may result, with the risk of patient injury.

WARNING !

Avoid pollutants in the ambient air.

Savina uses ambient air for ventilation and pollutants would enter the patient's airways.

The following precautions should be noted for mobile use:

WARNING !

Do not place the Savina ventilator on a patient's bed while in motion.

Ensure that the ventilator is properly secured to prevent it from falling or being knocked over.

WARNING !

To avoid risk of ventilator failure, always protect Savina from splashes and rain. The ventilator is not designed to be splash-proof.

* Draeger medical equipment fulfills the interference resistance requirements according to the product-specific standards or EN 60601-1-2 (IEC 60601-1-2). However, depending on the design of the mobile phone and circumstances of use, field strengths may occur in the immediate environment of a mobile phone that exceed the limits of the above standards and therefore cause interference.

CAUTION !

While ventilator is exposed to transport conditions, e.g. in an aircraft, vibration of patient circuits may affect flow measurement.

Appropriate Monitoring

The built-in monitoring features of the Savina ventilator ensure appropriate monitoring of ventilation therapy and therefore detect any undesirable changes in the following ventilation parameters:

- airway pressure, Paw
- expiratory minute volume, MV
- inspiratory O₂ concentration, FiO₂
- inspiratory breathing gas temperature, T
- apnea
- breathing rate
- inspiratory tidal volume

Changes in these parameters may be caused by:

- acute changes in the patient's condition
- incorrect settings and user error
- equipment fault conditions
- failure of power and gas supplies

WARNING !

In case of malfunction of any of the built-in monitoring, a substitute must be provided in order to maintain an adequate level of monitoring. The operator of the ventilator system must still assume full responsibility for proper ventilation and patient safety in all situations.

WARNING !

Back-up ventilation with an independent manual ventilation device

If a fault is detected in the Savina ventilator, so that its life-support functions are no longer assured:

- start ventilation using an independent ventilation device (resuscitation bag) without delay, if necessary with PEEP and / or increased inspiratory O₂ concentration.

Operating Concept

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Operating Concept

Ventilation Controls

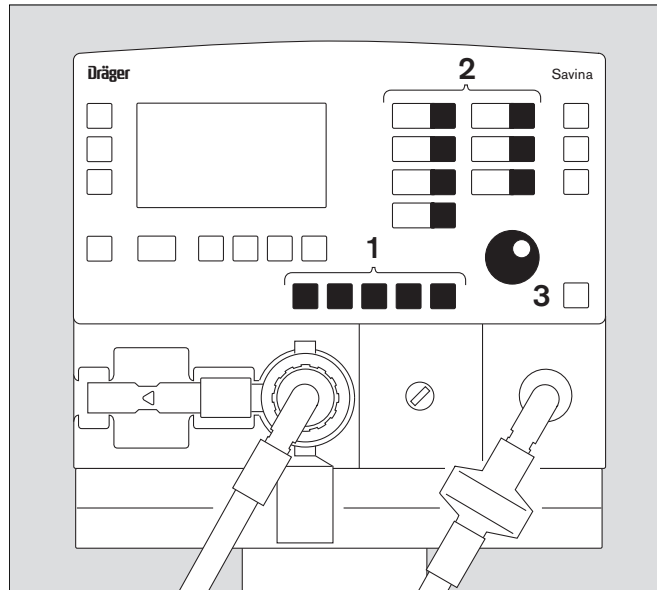
Setting Ventilation Parameters

Selecting the Ventilation Mode

Operating Concept

Ventilation Controls

- 1 Keys for selecting the ventilation modes:
 - **CMV A/C**
 - **SIMV**
 - **CPAP/PS**
 - **PCV+**
- 2 Keys for selecting / setting ventilation parameters:
 - Tidal volume **V_T**
 - Inspiration time **T_{insp}**
 - Frequency **Rate**
 - O₂-concentration **O₂**
 - Inspiratory pressure **P_{insp}**
 - Pressure support **ΔP_{supp.}**
 - Positive End-Expiratory Pressure **PEEP**
- 3 Central "turn and push" rotary dial knob for setting parameters and for selecting screen parameters.
To set, turn dial knob.
To confirm setting, press dial knob.



Setting Ventilation Parameters

- 2 To select a ventilation parameter, press the respective parameter key.
The yellow LED in the key lights up.
- 3 To set value of a ventilation parameter, turn dial knob.
The value is displayed next to the parameter key.
- 3 To confirm value, press dial knob.
The yellow LED in the key goes out.

NOTE: A new parameter value only becomes effective upon confirmation.

Derived parameters are displayed in an information window on the main screen page during the setting procedure.

Selecting the Ventilation Mode

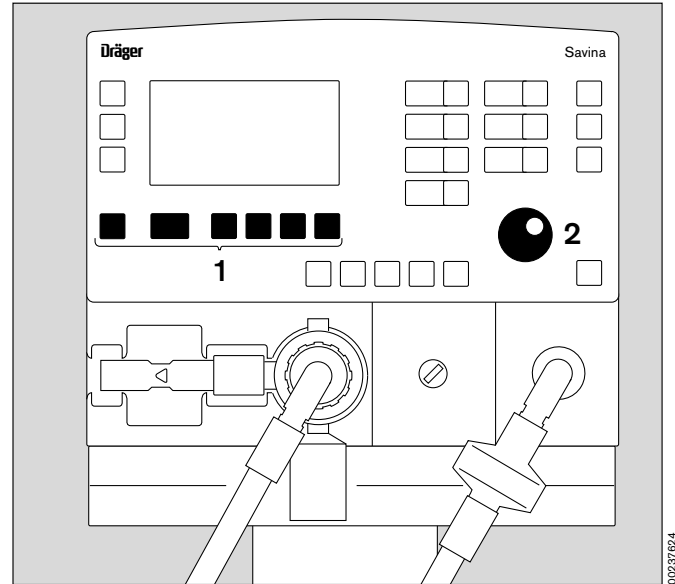
- 1 Hold down the appropriate key for about 3 seconds
or
- press key briefly and
- 3 confirm by pressing dial knob
The selected ventilation mode will now be activated.

For detailed instructions on setting ventilation modes, see page 56 and following.

Screen Operating Controls

1 Screen operating keys:

- » ☀/● « key for setting screen and display brightness (bright or dim),
- » **Waveforms** ▲■▼ « key for selecting the main screen page to display pressure and flow waveforms,
- » **Settings** ▷▷ « key for selecting the "Setting" screen page in order to set other ventilation parameters,
- » **Alarms** ▷▷ « key for selecting the "Alarms" screen pages in order to set and display alarm limits,
- » **Values** ▷▷ « key for selecting the "Measured values" screen page in order to display measured values,
- » **Config.** ▷▷ « key for selecting the "Configuration" screen page, for system defaults such as alarm volume or screen brightness.



2 Central "turn and push" rotary dial knob for selecting and setting the options displayed on the screen.

Select/set by turning dial knob.

To confirm, press dial knob.

Changing screen pages

To change to the next page:

- press the same key again.

To change to another page:

- press the respective key.

To change to the main page for pressure waveforms:

- press » **Waveforms** ▲■▼ « key.

Operating Concept

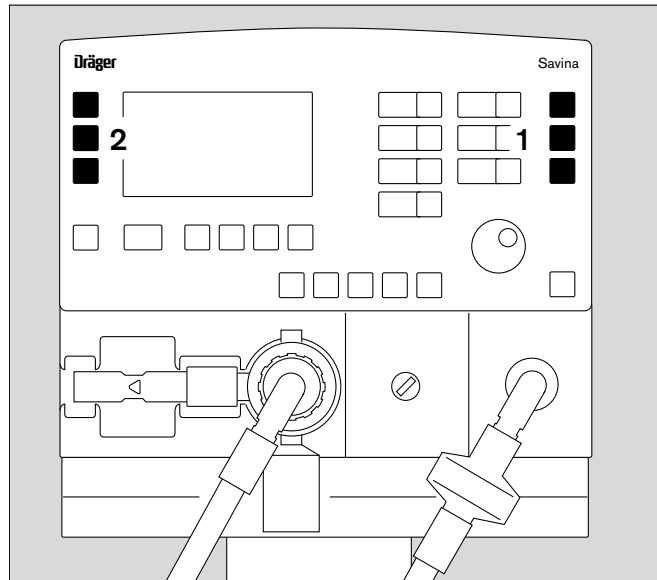
Keys for Routine and Auxiliary Functions

On Screen Information Window

Power Switch

Keys for Routine and Auxiliary Functions

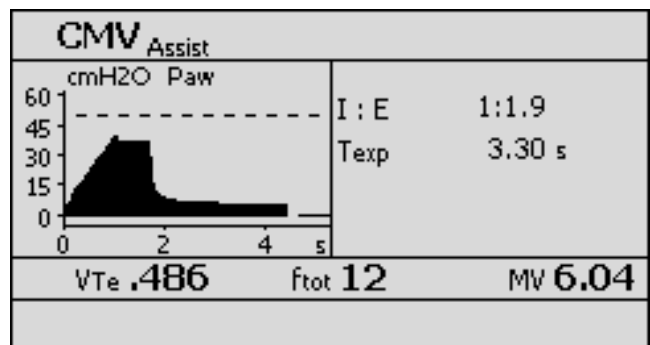
- 1 Frequently used keys for routine functions are positioned on the right-hand side of the front panel:
 - »**Alarm Silence**« key for muting audible alarm for 2 minutes,
 - »**Alarm Reset**« key for resetting or acknowledging alarm messages and for testing the LEDs and audible alarm,
 - »  **Lock**« key for protecting against inadvertent or unauthorized modification of ventilator settings.
- 2 Keys for auxiliary functions are positioned on the left-hand side of the front panel:
 - »  **Nebul.**« key for switching the integrated nebulizer on / off,
 - »**O₂ ↑ Suction**« key for pre-/post- oxygenation when performing bronchial suction,
 - »**Insp. hold**« key for manually activated inspirations and for manually extending inspiratory time.



On Screen Information Window

During setting of a ventilation parameter, Savina re-calculates derivative parameters (marked with an asterisk) and displays them in the information window on the main screen page.

The information window disappears when the parameter setting is confirmed.

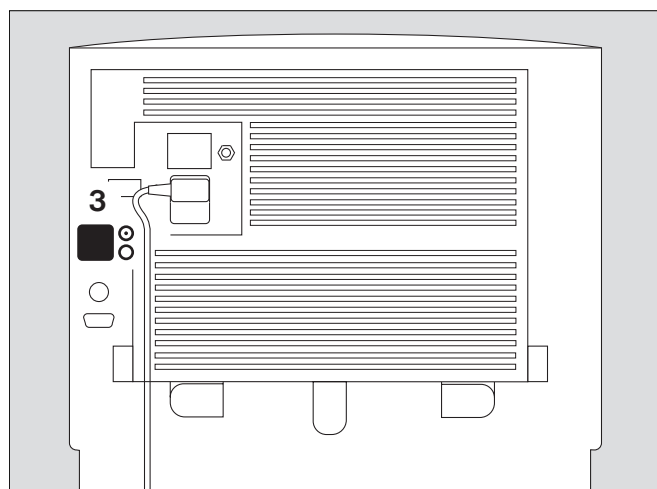


Power Switch

- 3 To switch the ventilator on / off.
Located on the back of the ventilator.

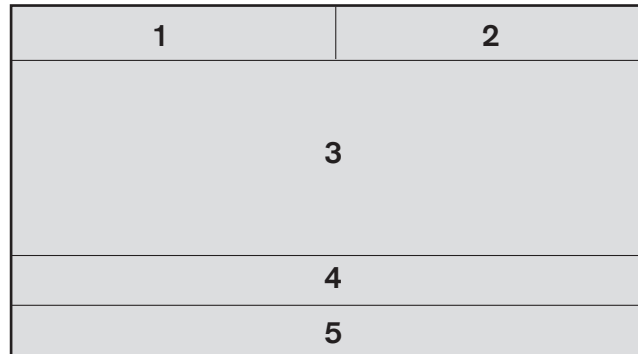
To switch on:

Press power switch to »  « = ON.



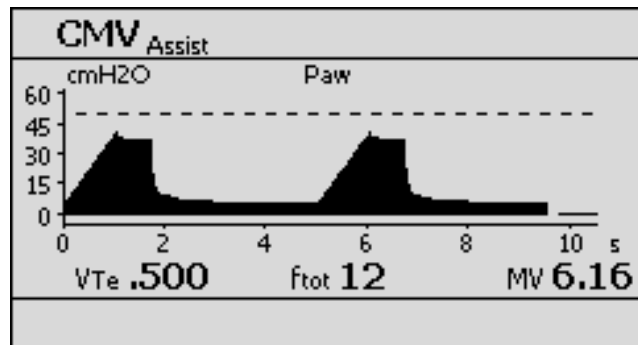
Structure of the Screen Pages

- 1 Ventilation mode display field
- 2 Alarm message display field
- 3 Waveforms and measured values display field
- 4 Measured values display field
- 5 Information bar



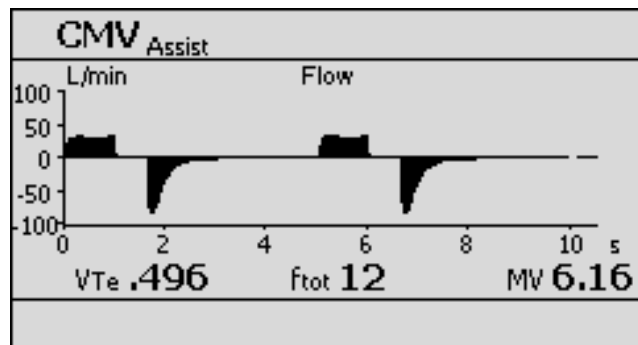
Main page

Displays a pressure curve as well as three measured values.
To configure the combination of measured values to be displayed, see page 87.
Includes the set P_{aw} alarm limit as a dashed line, see page 67.



Flow waveforms main page

Displays a flow waveform as well as three measured values.
To configure the combination of measured values to be displayed, see page 87.



Operating Concept

"Settings" Screen Page

"Alarms" Screen Page

"Values" Screen Page

"Settings" Screen Page

- Analog bar display of the airway pressure Paw.
- Setting menu for setting the supplementary ventilation parameters »Trigger«, »FlowAcc«, »AutoFlow« (optional).
- Setting menu for setting apnea ventilation, with the parameters »VTApnea«, »fApnea«.
- Setting menu for setting the sigh in the form of an intermittent PEEP.

»Settings 1/1« screen:

The "Settings" menu consists of a single page.

- To select parameters, turn dial knob.
The selected parameter is indicated by a bold frame.
- To activate parameter for setting, press dial knob.
The active parameter appears now light on a dark background.
- To set parameter, turn dial knob.
To confirm, press dial knob.

NOTE: For detailed instructions on setting ventilation modes, refer to page 56 and following.

SIMV _{PS}	
Paw	
cmH2O	0 15 30 45 60
Trigger	4 L/min
VTApnea	500 mL
FlowAcc	35 cmH2O /s
fApnea	12 bpm
AutoFlow	OFF
Settings 1 / 1	

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"Alarms" Screen Page

- For displaying alarm limits associated with measured values.
- For setting alarm limits.

»Alarms 1/1« screen:

The "Alarms" menu consists of a single page.

For detailed operating instructions, see "Setting alarm limits" on page 67.

CMV Assist	
Paw	
cmH2O	0 15 30 45 60
Paw	50 cmH2O
TApn.	15 s
MV	9.0 L/min
f _{tot}	35 bpm
	4.0 L/min
VTi	0.75 L
Alarms 1 / 1	

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"Values" Screen Page

- For displaying all measured values of the current ventilation mode.

For detailed operating instructions, see "Displayed Measured Values" on page 70.

»Values 1/2«:

Page 1 of 2 available pages.

PCV +	
Paw	
cmH2O	0 15 30 45 60
P _{peak}	26 cmH2O
VT _e	.323 L
P _{plat}	25 cmH2O
MV	5.06 L/min
P _{mean}	12 cmH2O
MV _{spn}	0.02 L/min
PEEP	5 cmH2O
FiO ₂	21 Vol. %
Values 1 / 2	

next page "Values >>"

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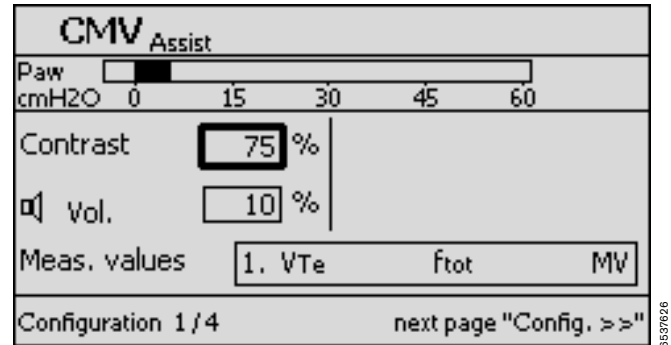
"Configuration" Screen Page

For setting equipment parameters:

- Screen contrast
- Alarm volume
- Measured values displayed
- Manual calibration for O₂ sensor 2
- FiO₂ and Flow Monitoring ON / OFF
- Pmax ON / OFF
- Plateau ON / OFF
- Language, date, and time
- MEDIBUS protocol
- Remote Service (optional)

»Configuration 1/4«:

Page 1 of 4 available pages of the Configuration menu.



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Changing Screen Pages

To change to the next page:

- press the same key again.

To change to another page:

- press the respective key for that page.

To change to the main page for pressure waveforms:

- press »Waveforms  « key.

For detailed instructions for use, see "Configuration", beginning on page 86.

»Stand by« Key

- 1 Positioned at bottom right of the front panel.

- To keep the ventilator ready for operation, e.g. after pre-setting.

or

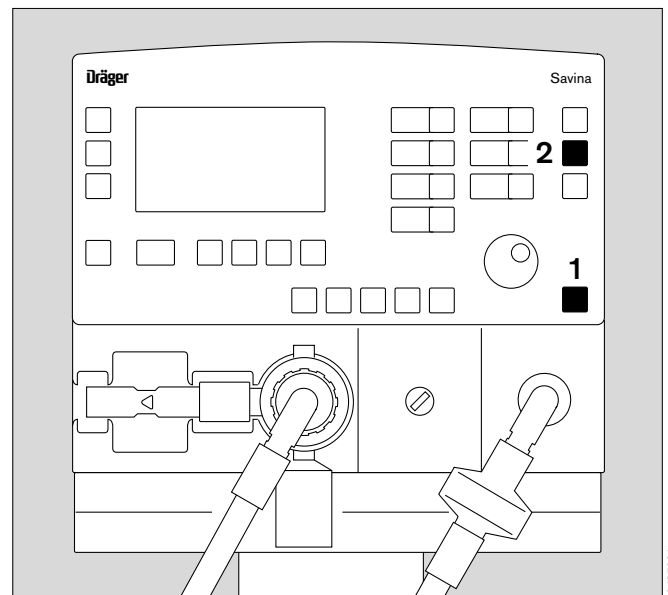
- to switch on ventilation.

To switch to standby:

- 1 Hold down »Stand by« key for at least 3 seconds and
- 2 press »Alarm Reset« key to confirm.

To switch on ventilation:

Press »Stand by« key briefly.



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Preparation

Assembly of Components

Assembling the Expiratory Valve

Installing the Expiratory Valve

Preparation

WARNING!

Do not place containers of liquids (such as infusion bottles) on top of or above the Savina ventilator. Liquids getting into the ventilator can cause equipment malfunction with the risk of patient injury.

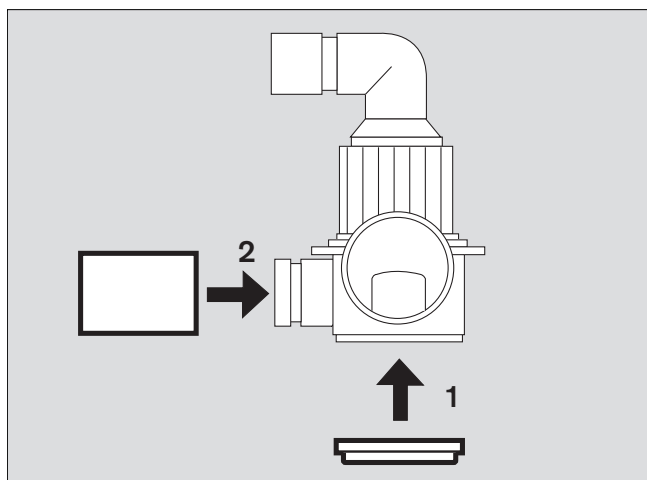
Assembly of Components

WARNING!

Always use components that have been properly cleaned and disinfected

Assembling the Expiratory Valve

- 1 Install membrane on expiratory valve body.
- 2 Push rubber grommet onto expiratory valve port.

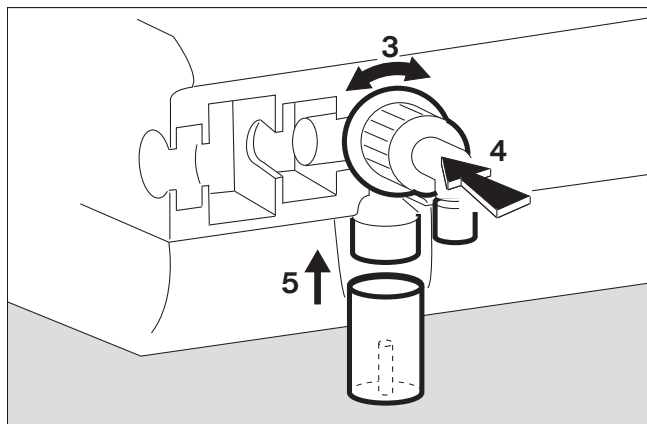


Installing the Expiratory Valve

- 3 Turn knurled knob counterclockwise to stop.
- 4 Insert expiratory valve.
- 3 Hand-tighten knurled knob clockwise.
- 5 Install water trap collecting jar.

WARNING !

Never operate Savina without a water trap on the expiratory valve – overcompensation for leakage might cause unintentionally high airway pressure and false triggering might occur.

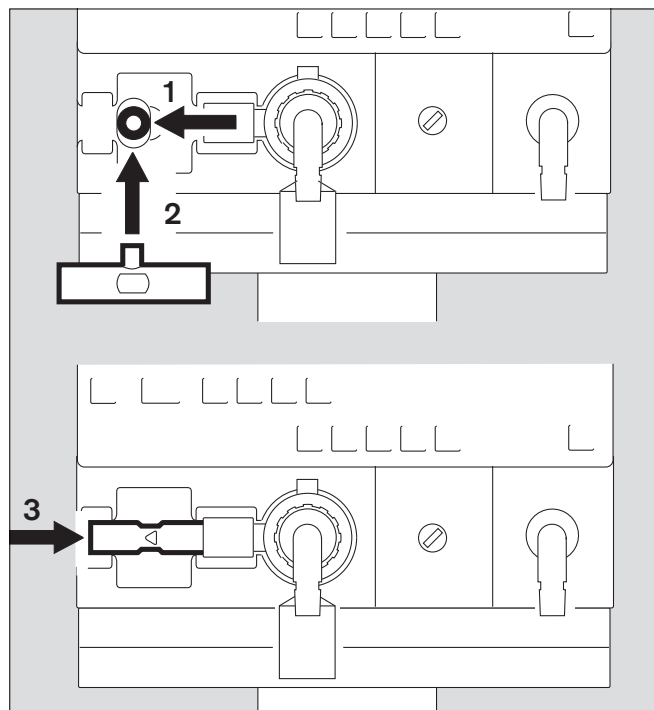


Installing the Flow Sensor

- 1 Slide flow sensor receptacle all the way to the left.
- 2 Insert flow sensor into its receptacle (plug facing the ventilator) and push into its socket as far as it will go.

Then:

- 3 Slide flow sensor fully to the right into the rubber grommet of the expiratory valve.



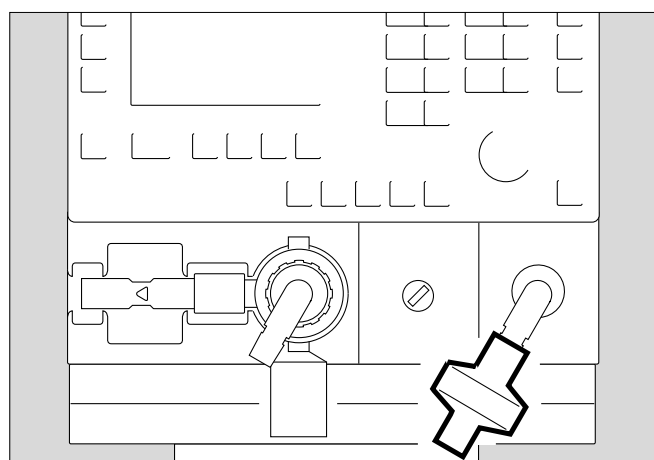
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Installing a Bacteria Filter

WARNING!

Always use a bacteria filter on the inspiratory port of the ventilator in order to protect the patient from contaminants in the ambient air drawn for ventilation.

- Install bacteria filter onto the inspiratory port of the ventilator.



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Precautions When Using Expiratory Bacteria Filters

Expiratory bacteria filters may be used.

Use of bacteria filters in the expiratory side of the patient circuit can cause an undesirable increase in breathing resistance.

Particularly when nebulizing aerosols or humidifying the breathing gas, resistance caused by a bacteria filter may slowly increase, leading to increased work of breathing and to intrinsic PEEP.

WARNING!

The flow resistance of bacteria filters placed in the expiratory side may be substantially increased by nebulized aerosols with the risk of impaired ventilation. If an expiratory filter is used during nebulization, airway pressures and flow should be monitored for any indication of increased expiratory resistance due to filter obstruction.

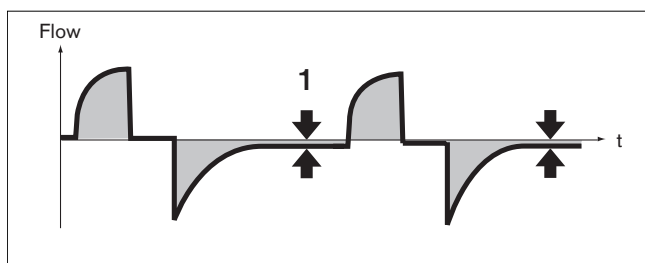
- 1 Increased breathing resistance due to a clogged bacteria filter may be recognized by the fact that expiratory flow has not returned to "0" at the end of expiration.

In this case, airway pressure at the end of expiration will still be above the set PEEP.

If airway pressure is more than 8 cmH₂O above the setpoint for PEEP, the ventilator will generate the alarm message:

!!! PEEP high

- Check bacteria filter and exchange if it proves to be the cause of the high PEEP alarm.



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Precautions When Using Heat/Moisture Exchangers

The use of a heat/moisture exchanger (HME, artificial nose) in the patient connection can increase breathing resistance considerably.

An increase in breathing resistance will lead to increased work of spontaneous breathing and/or greater trigger effort during assisted ventilation. Under unfavorable conditions, an increase in breathing resistance can also lead to intrinsic (inadvertent) PEEP.

The ventilator cannot directly monitor this breathing resistance in the patient connector.

Therefore:

- Check patient condition and the ventilator's measured values for volume more frequently.
- Carefully observe instructions for use of the heat/moisture exchanger (HME)!

WARNING!

Draeger cannot warrant or endorse the safe performance of heat/moisture exchangers with the Savina ventilator.

The user has to verify that the heat/moisture exchanger is covered by a technical safety certificate which guarantees its complete suitability for its intended use.

Do not use a heat/moisture exchanger simultaneously with a nebulizer or heated humidifier!

Risk of increased breathing resistance due to condensation.

WARNING!

The inspiratory breathing gas is warmed by the built-in blower of the ventilator. For appropriate cooling of the breathing gas it is therefore mandatory to use a patient circuit with a total length of no less than 1.2 m (4 feet). If shorter circuits would be used, the breathing gas temperature at the patient wye might exceed the permissible limit with the risk of patient injury.

WARNING!

Draeger cannot warrant or endorse the safe performance of third party humidifiers for use with the Savina ventilator. Specifically, the user has to assess the risks of delivery of breathing gas not maintained at a proper temperature associated with different humidifier designs. It is strongly recommended to use the electronic temperature monitoring feature of the ventilator if no proximal airway temperature monitoring is performed by the humidifier used.

Increased pneumatic resistance in the inspiratory line caused by a humidifier may result in less accurate airway pressure readings.

We recommend contacting the manufacturers/ distributors of third party humidifier devices about compliance of their products with the requested performance characteristics.

- Prepare humidifier following its Operating Instructions.
- 1 Attach humidifier to mount below ventilator with rail clamp and secure clamp mechanism (screws, lever).

WARNING!

Do not use a heat/moisture exchanger (HME) simultaneously with a heated humidifier!

Risk of increased breathing resistance due to condensation.

NOTE: Regarding the use of heated patient circuits.

In the event of a ventilator failure, the patient can breathe through the inspiratory relief valve. However, circuits with a small effective inner diameter such as pediatric and heated patient circuits with internal hot wires may lead to high breathing resistance.

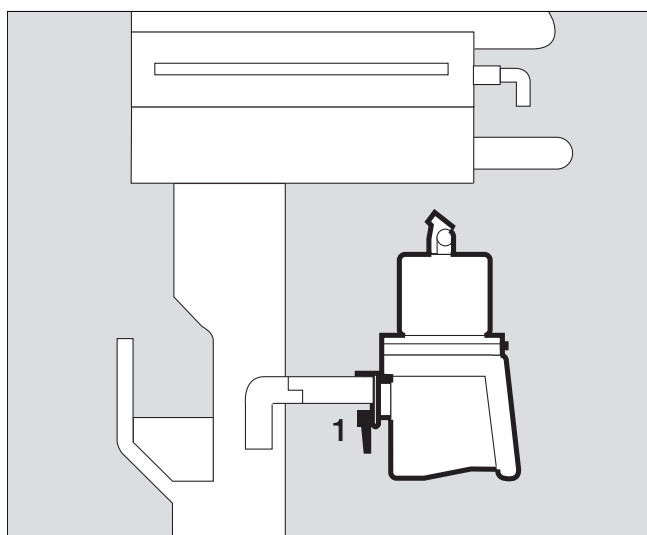
Placement of the humidifier

The hinged circuit support arm can be mounted to either side of the ventilator, depending on the desired position of the ventilator in relation to the patient bed.

For a ventilator placed **to the right** of the patient bed

- Turn both ventilator ports to the left.
- Swivel humidifier to the left

NOTE: In subsequent descriptions, the ventilator circuit system is depicted as being mounted **to the left**.



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When ventilating infants

- Always use a humidifier suitable for ventilating small patients
- Always use appropriately sized patient circuits.

NOTE: When using heated pediatric circuits with internal heating wires, please note:
In the event of a ventilator failure, the patient can continue breathing through the inspiratory relief valve. A high breathing resistance is to be expected, however, due to the small internal diameter of the breathing circuit.

Connecting the patient circuit.**WARNING!**

In order to avoid any risk of electric shock in the event of faulty grounding of patient monitoring equipment, do not use antistatic or electrically conductive patient circuits*

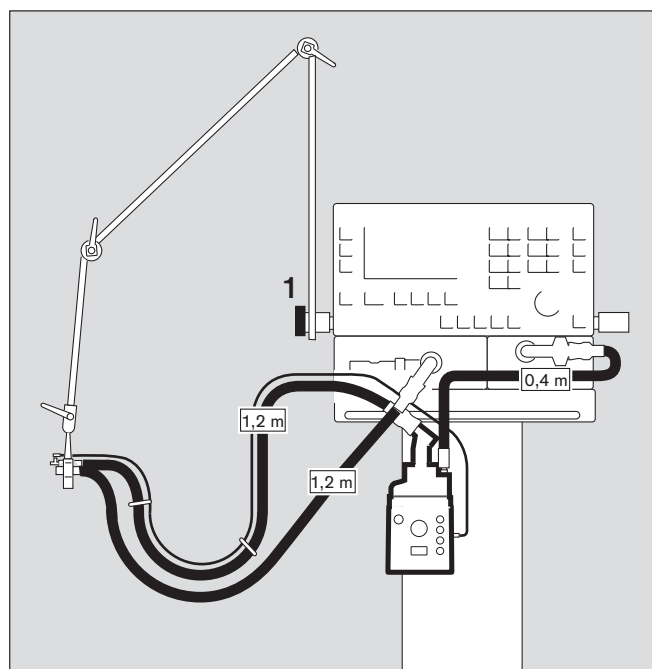
- 1 Attach circuit support arm to the rail on the left-hand side of the ventilator and tighten screws.
- Install bacteria filter on the inspiratory port of the ventilator.
 - Connect ventilator circuit segments of appropriate lengths.
 - Turn ventilator ports in the direction of the circuit.
 - Connect wye.
 - Clip wye into its bracket at the end of the circuit support arm.

WARNING!

Do not use inspiratory circuits with a total length of less than 1.2 m (4 feet) between humidifier and wye. Otherwise risk of excessive breathing gas temperatures!

WARNING !

Do not use humidifiers without temperature regulation. Otherwise risk of excessive breathing gas temperature!



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* NOTE: IEC 601-2-12 "Lung Ventilators" does not consider the use of antistatic or electrically conductive materials for patient circuits of a lung ventilator a contribution to increased safety. To the contrary, the use of such materials increases the risk of electric shock for the patient and the fire risk associated with oxygen

Supplies and Connections

Electrical Power Supply

The ventilator is designed for a line voltage of:
100 V to 240 V AC, 50/60 Hz.

Savina is equipped with an auto-switching power supply that adapts to the local line voltage.

- Insert plug into the power outlet.

WARNING !

This device is to be used only in rooms with line power installations complying with national safety standards for hospital patient rooms. (e.g., IEC 601.1, "Safety of Medical Equipment).

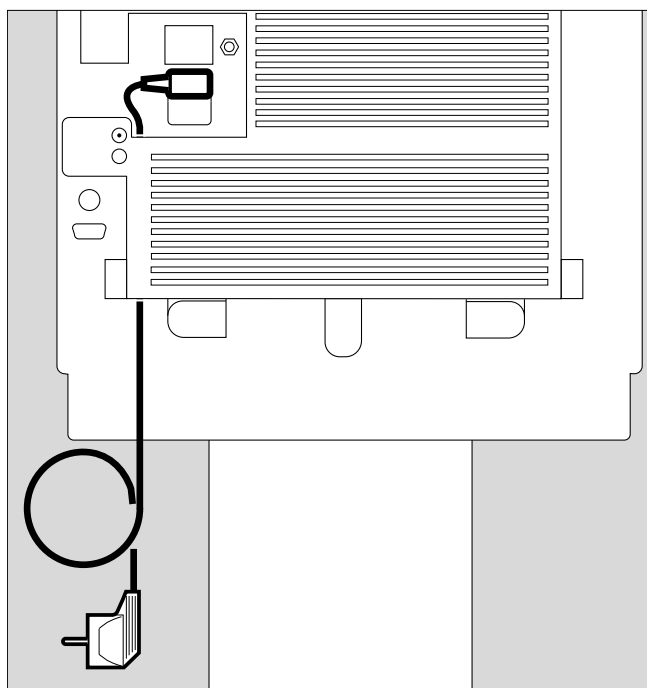
To maintain grounding integrity, connect only to a "hospital grade" receptacle. Always disconnect supply before servicing.

Precautions when using a power strip for auxiliary equipment (available option)

WARNING !

Connecting other devices to the same extension power strip may, in the event of grounding failure, cause the leakage current to the patient to increase beyond the permissible values.

In this case, the risk of electric shock cannot be safely excluded.



Connecting to an external battery or to an external DC supply on board

Please refer to "Technical Data", page 137, for external battery specifications)

WARNING !

Use rechargeable batteries ONLY.

Because of the charging feature of the Savina DC power supply, connecting non-rechargeable batteries might lead to a risk of explosion when operating the ventilator from line power.

CAUTION !

Do not connect AC/DC power supplies to the DC input.

- Connect to external battery with the DC battery cable S, part no. 84 14 092 (only 12 V or 24 V) or connect to an external DC supply on board via the DC cable S, part no. 84 14 048.

NOTE: The ventilator-side connector of these cables is coded. Savina uses the coding to recognize whether it is connected to an external battery or an on-board DC supply.

Verify correct polarity

black = –
red = +

The ventilator will ignore an incorrectly connected battery or on-board DC supply.

NOTE: While operating the ventilator on-board, always connect to the on-board power supply.

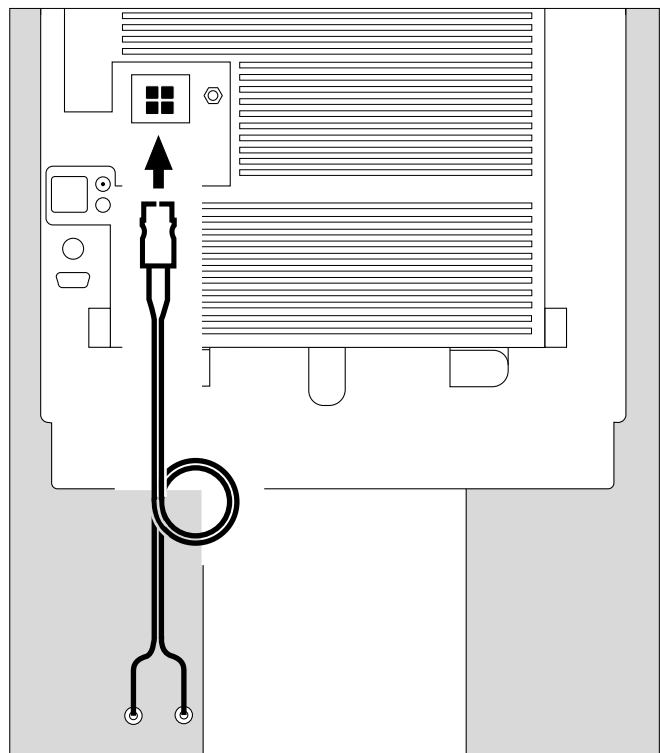
- Insert connector into the DC input receptacle in the back of the ventilator.

NOTE: Always check that the external battery is sufficiently charged before using the ventilator on a transport. See "Checking Readiness for Operation" on page 43.

Internal battery

In case of a line power failure or a discharged or not connected external battery, Savina will automatically switch to supply power from its internal battery.

NOTE: Always check that the external battery is sufficiently charged before using the ventilator on a transport. See "Checking Readiness for Operation" on page 43.



WARNING !

Always use medical grade oxygen that is dry and free from contaminations. Contaminated gas may cause ventilator malfunction.

Ensure a reliable source of 100 % oxygen. Brief fluctuations in the concentration may lead to an incorrect calibration of the O₂ sensor.

Supply pressure must be between 39 and 87 psi (2.7 to 6 bar).

- Screw high pressure oxygen hoses to socket on the side of the ventilator and supply oxygen from a wall terminal or O₂ cylinder. When supplying from an O₂ cylinder, the reserve gas supply should be calculated.

NOTE: An optional screw-on elbow adapter for making the O₂ connection to the ventilator is also available.

NOTE: Due to the blending of gases, a set O₂ concentration will be reached after 3 minutes from the time of setting. The blending might take somewhat longer, however, when minute volumes less than 2 L/min are delivered.
A "!!! FiO₂ high" or "!!! FiO₂ low" alarm will indicate that the set concentration has not been reached yet.

Expected operating time when using an O₂ cylinder supply

When using an increased O₂ concentration (above 21 Vol. %), Savina ventilates with a mixture of air (delivered by its blower) and O₂.

When supplying O₂ from a cylinder, the maximum possible operating time depends on the O₂ reserve (as well as on the delivered O₂ concentration and the ventilation parameters).

For example:

Cylinder pressure measured at the pressure regulator on the

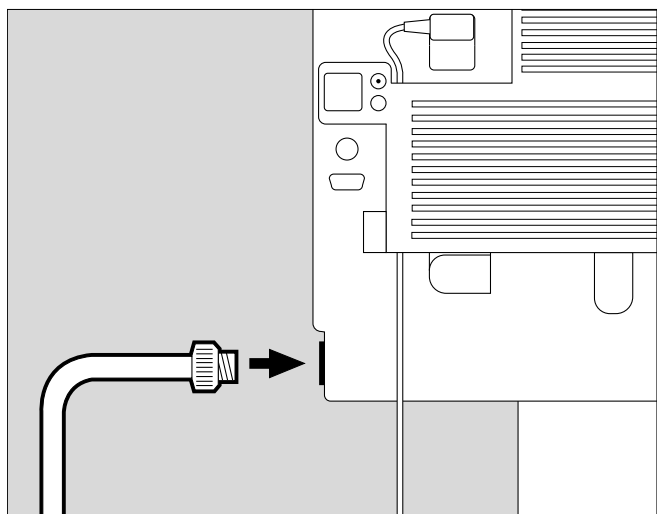
O₂ cylinder: 2400 psi

O₂ cylinder size: E- cylinder

O₂ reserve: 622 L

Expected operating time with the following parameters:

- | | |
|---|--|
| – Ventilation mode | »CMV« |
| – Frequency »f« | 10 bpm |
| – Tidal volume »V _T « | 600 mL |
| – Minute volume »MV« | 10 bpm x 0.6 L = 6 L/min |
| – Selected O ₂ concentration »O ₂ « | 50 % by vol. resp.
O ₂ fraction: 0.5 |



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The ventilator takes into account the O₂ concentration of 21 Vol. % in the air.

$$\begin{aligned}
 \text{Expected operating time} &= \frac{\text{Gas reserve [L]}}{(\text{O}_2 \text{ fraction} - 0.21) \times \text{MV [L/min]}} \\
 &= \frac{622 \text{ L}}{(0.5 - 0.21) \times 6 \text{ L/min}} \\
 &= \frac{622}{0.29 \times 6} \\
 &= \text{approx. 357 min} \\
 &= \text{approx. 6 h}
 \end{aligned}$$

With a higher O₂ concentration, the operating time is reduced accordingly.

Once the reserve O₂ from the cylinder has been used up, the delivered O₂ concentration will be reduced to 21 Vol. %.

Before Using the Ventilator on a New Patient

- Check readiness for operation (page 43).

WARNING !

The ventilator is ready for operation only when:

- it is completely assembled with all required auxiliary equipment in place,
- all sensors are calibrated (O₂, Flow),
- all tests of readiness for operation have been completed successfully.

Nurse Call System (Available Option)

Connection on the rear panel of Savina intended for the transmission of alarm signals to a central hospital alarm system.

WARNING !

- Installation of the Savina nurse call kit should only be performed by DraegerService or factory trained and authorized service personnel.
- Have a qualified electrician perform the installation of the round 6-way DIN female connector to the line of the central alarm system.

Savina activates the nurse call by closing contacts 3-5 whenever a WARNING level alarm (three exclamation marks !!!) is displayed.

- Insert plug into the »  « socket on the back panel of the ventilator and screw in tightly.

WARNING !

- The operator of the ventilator must still assume full responsibility for ventilation monitoring via the Savina screen when the nurse call is connected.
- Only warning messages (!!!), i. e. alarm messages with top priority, will activate the nurse call.
- Regularly check on-screen messages.

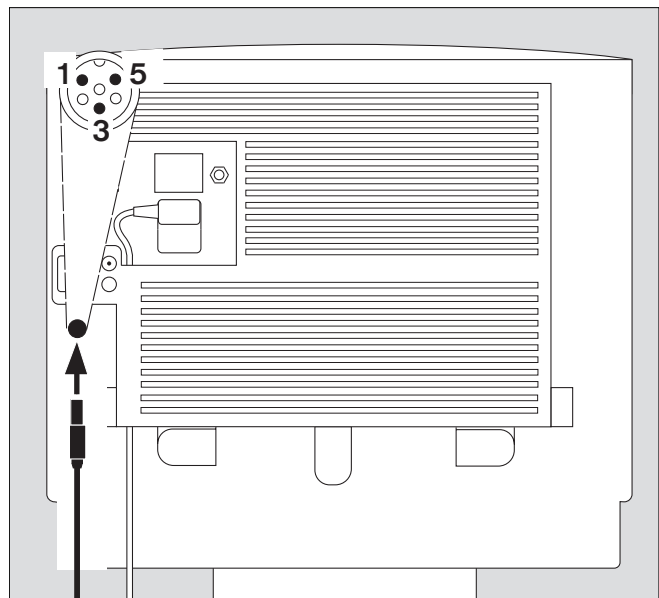
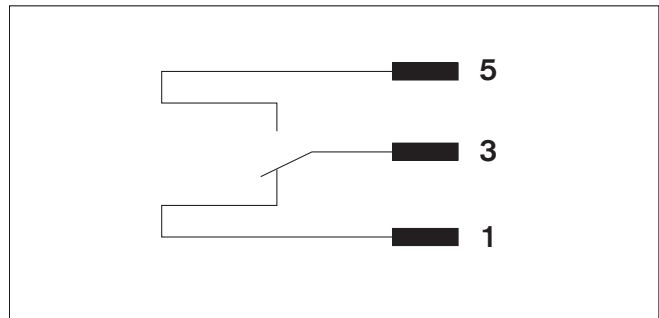
Warning messages that are transmitted via nurse call appear with 3 exclamation marks in the upper line on screen, see page 68. Caution and advisory messages will **not** be transmitted. The nurse call system will also be activated when the original enunciator in the ventilator is faulty.

- Test nurse call system for proper functioning after it has been connected.

WARNING !

A fault within any component of the combination between the nurse call and the central alarm system of the hospital (e. g. inside the Savina nurse call electronics, the Savina power supply, or the hospital alarm equipment) may result in a failure of a proper nurse call function.

NOTE: Hospital central alarm system connections are usually of single-channel design (non-redundant). Therefore, the electronics of the Savina nurse call are also of single-channel design.



Technical data

Potential-free DC contact

Input voltage max. 40 V DC

Input current max. 500 mA

Switching power max. 15 W

Checking Readiness for Operation

Perform immediately before using the ventilator on a patient:

The following functional tests are performed:

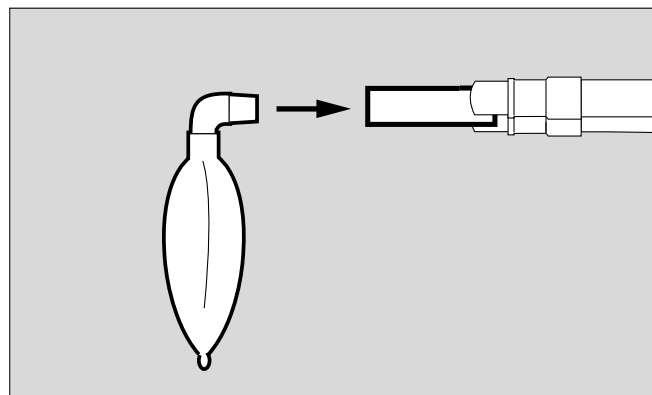
(Please refer also to the Checklist on page 46).

- Function of status lights, displays, and audible alarm
- Ventilation function
- Function of PEEP valve
- Measurement of expiratory minute ventilation
- Measurement of inspiratory O₂ concentration FiO₂
- Lower alarm limit for minute ventilation
- Lower alarm limit for P_{aw}
- Power failure alarm
- O₂ alarm

Connecting a test lung to the wye.

The test lung consists of an elbow mask adapter for connection to the wye, a 7 mm catheter adapter for simulating airway resistance, and a 2 L breathing bag (part no. 84 03 201) for simulating lung compliance

- Connect elbow mask adapter to the patient wye.

**Switching ventilator on**

- Set power switch on the back panel of the ventilator to »  « position

Savina now performs a power-on self test

- Wait for the 12 second test to complete.

Savina automatically adapts its blower speed to the gas requirements of the patient. When starting a ventilation or adjusting ventilation parameters, a slight whining noise may be heard temporarily. This is normal.

Preparation

Checking Readiness for Operation

Checking LEDs and audible alarm

After completing the 12 second test phase, the ventilator lights all LEDs, all lights in the keys, as well as status lights for trigger and power. The audible alarm is briefly activated.

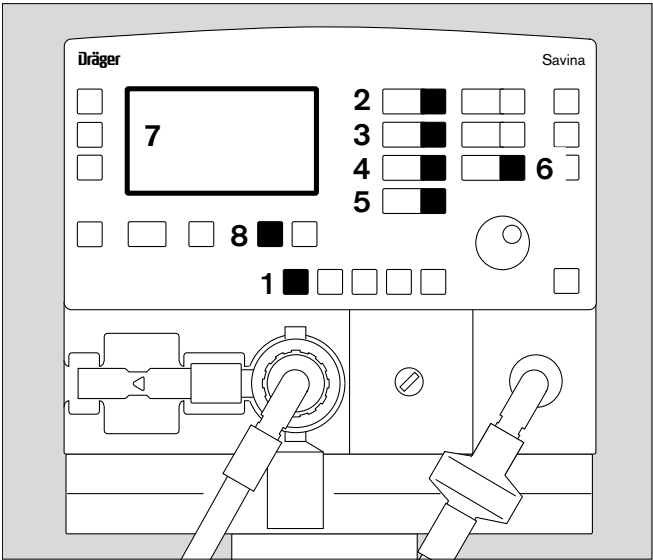
The status light indicating the current power source is continuously lit.

Checking ventilatory function

- 1 Ventilation mode »CMV«
- 2 »VT« 800 mL
- 3 »Tinsp« 2 s
- 4 »Rate« 10 bpm
- 5 »O2« 60 Vol.%
- 6 »PEEP« 10 cmH2O
- 7 »Trigger« 5 L/min set on screen page »Settings 1/1«
- »FlowAcc« 35 cmH2O/s (on screen page »Settings 1/1«)
- »Pmax« (on screen page »Configuration 2/4«)
- »Plateau« (on screen page »Configuration 2/4«)

Savina now ventilates the test lung with the set ventilation pattern.

- 8 Select »Values 1/2« with »Values >>>« key.
- The bar graph in the screen shows airway pressure fluctuating between inspiratory and end-expiratory pressure in the rhythm of inspiration and expiration.



Display PEEP:

PEEP 10 cmH2O
tolerance ±2 cmH2O

Display minute ventilation:

MV 7.8 L/min
tolerance ±1.0 L/min

Display O2 concentration:

FiO2 60 %
tolerance ±3 Vol. %

CMV Assist			
Paw			
cmH2O	0	25	50 75 100
Ppeak	50	cmH2O	VTe .784 L
Pplat	46	cmH2O	MV 7.85 L/min
Pmean	19	cmH2O	MVspn 0.00 L/min
PEEP	10	cmH2O	FiO2 60 Vol.%
Values 1/2		next page "Values >>>"	

- Detach test lung from wye.
An alarm message will appear on screen:
!!! Airway pressure low
Display after approximately 45 seconds
MV 0 L/min
+ 0.5 L/min tolerance

- Reconnect test lung to wye.

Power failure test

- Pull AC or DC plug from external power source.
The ventilator should switch to its internal battery and continue ventilation.

Display

!! Int. battery activated

Wait about 30 seconds.

The display for remaining battery capacity (on the main screen page) will show the internal battery charge level, see page 51.

- Plug unit back into AC or DC.

Testing the O₂ alarm

- Pull quick connect of O₂ supply hose from gas outlet:
Intermittent audible alarm and display message:

!!! O₂ supply down

Savina will ventilate with Air only.

- Reconnect quick connect to the O₂ source.

A warning message

!!! FiO₂ low

may appear briefly.

- Press »Alarm Reset« key.

If all tests of readiness for operation have been completed successfully, the ventilator is now ready for operation.

- Do not use ventilator unless all the test steps have been completed.

Checklist

Perform checks before each use.

Ventilator is completely assembled and ready for operation,
test lung is connected.

What	How	Target
Function of lights/LEDs and audible alarm	Switch ventilator on:	All lights and LED digits light up, the audible alarm starts sounding.
Function of power failure audible alarm	Keep »Alarm Reset« key pressed for approximately 3 seconds:	Audible alarm starts.
Apnea alarm	Switch to CPAP ventilation mode, set PEEP to 10 cmH ₂ O. Simulate spontaneous breathing by cycling the test lung (pressing and releasing), then stop this simulation. Press »Alarm Reset« key.	Upon expiration of the apnea alarm delay T_{Apnea} : Audible alarm starts, warning message appears on screen: !!! Apnea
"PEEP high" alarm Emergency venting valve	Switch to CMV ventilation mode, Set Paw  to 100 cmH ₂ O, Block flow sensor. Press »Alarm Reset« key.	Airway pressure is reduced, audible alarm starts, red alarm light starts blinking, warning message appears on screen: !!! PEEP high
"Airway pressure high" alarm	Set Paw  below current maximum airway pressure. Set Paw  to 100 cmH ₂ O, Press »Alarm Reset« key.	Audible alarm starts, red alarm light blinking, warning message appears on screen: !!! Airway pressure high
"MV low" alarm	Set MV  above currently measured value of MV. Set MV  back to a value below currently measured value of MV. Press »Alarm Reset« key.	Audible alarm starts, red alarm light blinking, warning message appears on screen: !!! MV low
Test for leaks in patient circuit	Set low ventilator Rate , long inspiratory time T_{insp} , and high flow acceleration FlowAcc . Observe pressure waveform.	Plateau pressure remains constant.

WARNING !

Do not use ventilator if the tests are not completed successfully.

Reset all settings and alarm limits to values defined by accepted hospital protocols.

AC Line Power and Battery Operation

Displaying the Active Power Supply	48
Operation from AC Line Power	49
Operation From an External Battery or an On-Board DC Power Source	49
Operation From the Internal Battery	50

AC Line Power and Battery Operation

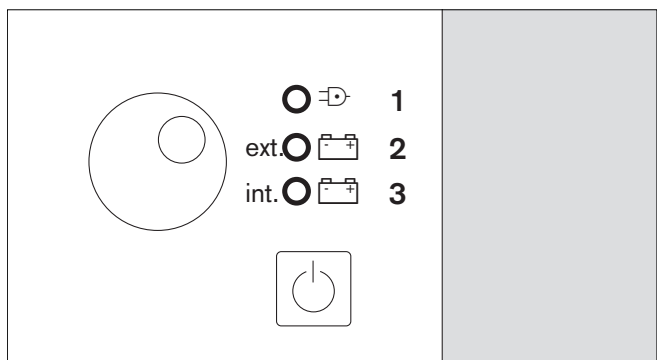
Displaying the Active Power Supply

The power supply status is indicated by three status LEDs to the right of the control knob.

- 1 Line power status light »«
- 2 Status light for on-board DC »ext. «
(e.g. in an ambulance or helicopter) or external battery (e.g. when used with a wheeled transport stretcher).
- 3 Status light for internal battery »int. «.

Color coding for the status lights

- | | |
|---------|--|
| green | power source available |
| yellow: | battery charging |
| off: | power source not available |
| red: | excessive temperature or excessive voltage |



Power source priorities

Savina automatically prioritizes the use of the different power sources.

AC line power:

Savina automatically switches to AC line power when available and charges the internal and external batteries.

WARNING !

Leave Savina connected to AC line power only in well ventilated rooms (minimum air circulation: 1.2 m³/h). Charging batteries generates hydrogen that, with sufficient concentration, could cause an explosion with the risk of personal injury.

External battery or on-board DC power:

While connected to a DC power source, Savina will automatically switch to the external battery or on-board DC supply in case of an AC line power failure.

Internal battery:

The internal battery is used when neither AC line power nor a DC power source is available.

Operation from AC Line Power

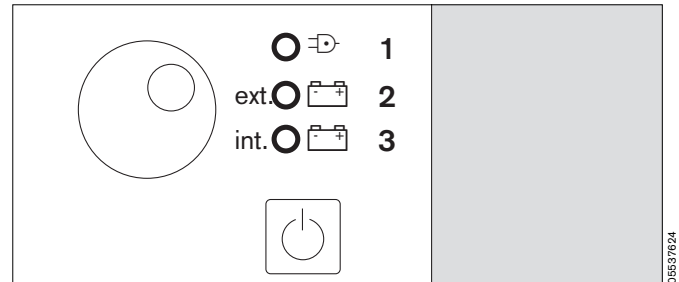
Display (example):

- 1 Savina connected to AC line power:
Status light »« is lit green.
- 2 External battery not fully charged:
Middle status light »ext. « is lit yellow.
- 3 Internal battery fully charged:
lower status light »int. « is lit green.

When operating the ventilator on AC line power, the internal battery is charged first. Only when this battery is fully charged (status light green), an external battery will be charged next.

Savina automatically detects the voltage of the external battery (12 V or 24 V).

Once the respective battery is fully charged, continued trickle charging will compensate for self-discharge of the batteries.



Operation From an External Battery or an On-Board DC Power Source

In case of AC line power failure, Savina will switch, without interruption, to an available DC source.

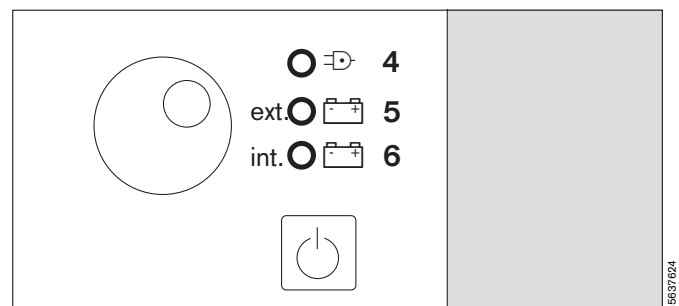
The supply may be one of two different types:

- supply via an external rechargeable battery
or
- supply via an on-board DC supply

Savina will recognize whether an external battery or an on-board DC power system is connected (see page 39). This prevents Savina from attempting to charge an on-board DC system.

Display (example):

- 4 No AC line power:
upper status light »« off
- 5 Supply from an external battery:
middle status light »ext. « is lit green
- 6 internal battery fully charged:
lower status light »int. « is lit green.



AC Line Power and Battery Operation

Operation From the Internal Battery

Total operating time with an external battery depends on the type and charge level of the battery connected.

For details of the available operating time, please refer to "Technical Data", page 137

If the external battery is discharged or if there is no DC on-board system, Savina automatically switches to the internal battery. See "Operation From the Internal Battery" on page 50

When AC line power is restored, Savina will automatically switch back to AC power and will charge both batteries.

NOTE: The on-board DC system will only charge the internal battery while Savina is switched on.

Operation From the Internal Battery

If the ventilator is not connected to an external DC source or the external battery is discharged, Savina will switch, without interruption, to its internal battery in case of AC line power failure.

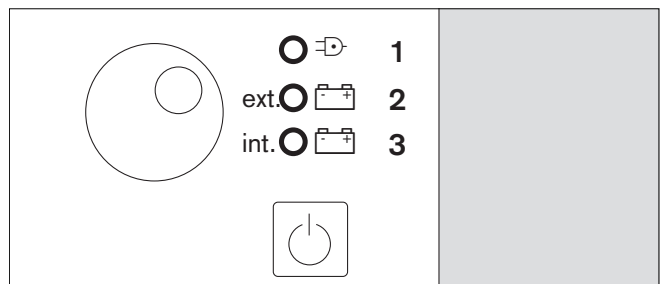
Display:

- 1 No AC line power:
upper status light »« off
- 2 No supply from an external battery or on-board DC source:
middle status light »ext. « off
- 3 internal battery fully charged:
lower status light »int. « is lit green.

When switching automatically to the internal battery, the following caution message is displayed:

!! Int. battery activated

- Press »**Alarm Reset**« key to acknowledge message.
The message continues to be displayed as an advisory:
! Int. battery activated

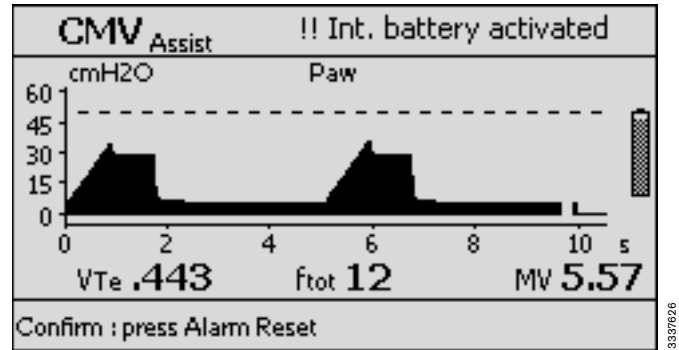


Battery level display

About 15 seconds after switching over to the internal battery, a battery level display (remaining capacity display) is activated.

- The charge level of the internal battery is displayed on the main screen page as a hatch pattern inside a battery symbol. This indicator can be used to assess the remaining operating time for Savina.

NOTE: Remaining capacity is only displayed when operating from the internal battery.
The battery charge symbol is not displayed when operating from the external battery.



The display of remaining capacity can be expected to follow a constant gradient during constant ventilation (i.e. ventilation using constant blower speed). For example, a change in the reading from 70 % to 50 % takes roughly the same time as a change in the reading from 30 % to 10 %.

WARNING !

An uneven discharge gradient indicates that the battery is insufficiently charged or defective.
In this case, the remaining capacity can be expected to be zero at any moment.

When the remaining capacity reaches 30 % and 20 % respectively, a caution message

!! Int. battery low

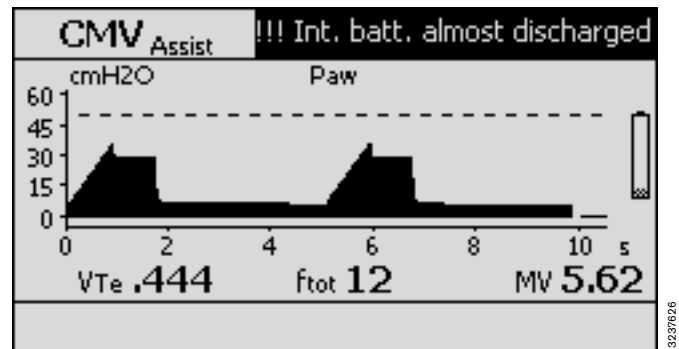
is triggered.

This can be acknowledged by pressing »Alarm Reset«.

If the remaining capacity falls below 10 %, the warning message

!!! Int. batt. almost discharged

appears.

**WARNING !**

If the WARNING "!!! Int. batt. almost discharged" appears, Savina could stop working at any moment.
Immediately reconnect Savina to AC line power, a charged external battery, or DC on-board system in order to prevent any interruption of ventilation.

Notes on operating time when supplying DC from the internal battery

The total operating time is the time from switching over to the internal battery until device failure.

Total operating time depends on the internal battery charge level. For the total operating time of a new, fully charged battery, see page 137.

To ensure a long total ventilator operating time, do not set »FlowAcc« to unnecessarily high values in battery operation.

Total operating time depends on the blower speed. Upon switching over to the internal battery, a speed limit is activated which reduces the flow delivery capability.

Remaining capacity may be rapidly reduced if the blower is under increased load, e.g. due to increased ventilation pressure.

When the blower is under reduced load, the remaining capacity may be increased due to physical effects on the battery. This extends the total device running time.

If, at the time of changing over to the internal battery, a remaining capacity of considerably less than 100 % is indicated, the internal battery was not sufficiently charged beforehand or has exceeded its life. If the internal battery has not been used for some time and its capacity appears reduced, battery capacity may be restored by one or two charge/discharge cycles which allow the battery to be discharged almost totally and then to be charged fully.

CAUTION !

Discharging the internal battery repeatedly without a full recharge in between may damage the battery

After using Savina with power from its internal battery

- Reconnect Savina to AC power in order to fully recharge the internal battery (and the external battery if connected).

While Savina is switched on, the internal battery is charged by the external battery or the on-board network. When Savina is switched off, charging only takes place if connected to AC line power. For charging times, please refer to "Technical Data" on page 138.

NOTE: Always ensure that the internal battery is charged with AC power or from the DC on-board system. The internal battery powers the two O₂ sensors, even while Savina is switched off. Savina therefore delivers valid O₂ readings even immediately after switching the ventilator on. When the internal battery had been fully discharged, Savina does not provide any O₂ readings for the first 20 minutes after switching on. O₂ blending is performed at reduced accuracy during this time.

Operation

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Operation

Precautions During Operation

WARNING !

Always use ventilator that has been cleaned and disinfected and has been successfully tested to be ready for operation.

WARNING !

In case of a fault in any of the built-in monitoring a substitute has to be provided in order to maintain an adequate level of monitoring. The operator of the ventilator must still assume full responsibility for proper ventilation and patient safety in all situations.

WARNING !

If a fault is detected in the ventilator and its life-support functions are in doubt, ventilation must be started without delay with an independent ventilation device (resuscitation bag) – using PEEP and/or increased inspiratory O₂ concentration where necessary and appropriate. The unit should then be removed from use and serviced by an authorized service technician.

WARNING !

- Always use extreme caution when using oxygen!
- Oxygen intensely supports any burning!
No smoking, no open fire in areas where oxygen is in use!
- Always provide adequate ventilation in order to maintain ambient O₂ concentrations < 24 %.
- Always secure O₂ cylinders against tipping, do not expose to extreme heat.
- Do not use oil or grease on O₂ equipment such as tank valves or pressure regulators.
Do not touch with oily hands. Risk of fire!
- Open and close valves slowly, with smooth turns.
Do not use any tools.

WARNING !

Always heed all precautions and follow all hospital protocols with respect to the administration of oxygen. Make adjustments to the FiO₂ according to the blood gas values measured.

WARNING !

Do not block air intake. Ventilator malfunction will result.

WARNING!

Do not place containers of liquids (such as infusion bottles) on top of or above the Savina ventilator. Liquids getting into the ventilator can cause equipment malfunction with the risk of patient injury.

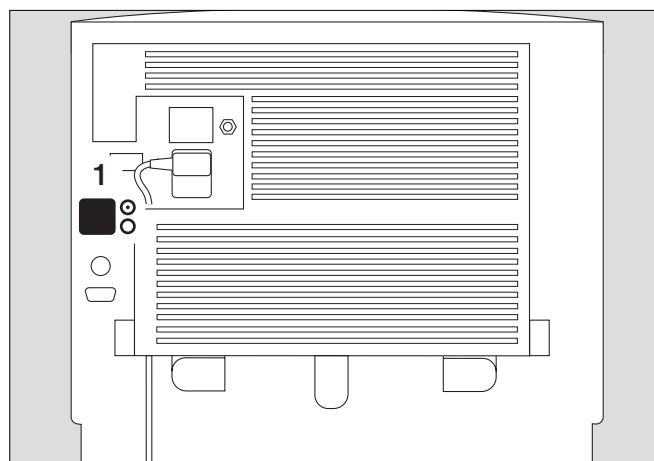
Perform tests of readiness for operation according to checklist, see page 46.

Starting Up

Switching on

- 1 Turn main switch on the back of the ventilator to » ⏻ «.
Savina now performs a power-up self test procedure.
- Wait for the 12-second test phase to be completed.

At the end of this self test, the ventilator automatically starts ventilation with the last ventilation mode and associated ventilation parameters set.



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During the self-test, the start-up page appears, showing the software version.



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After the start-up page, the main page appears.

- Check settings in the display fields next to the parameter keys and adjust as necessary.

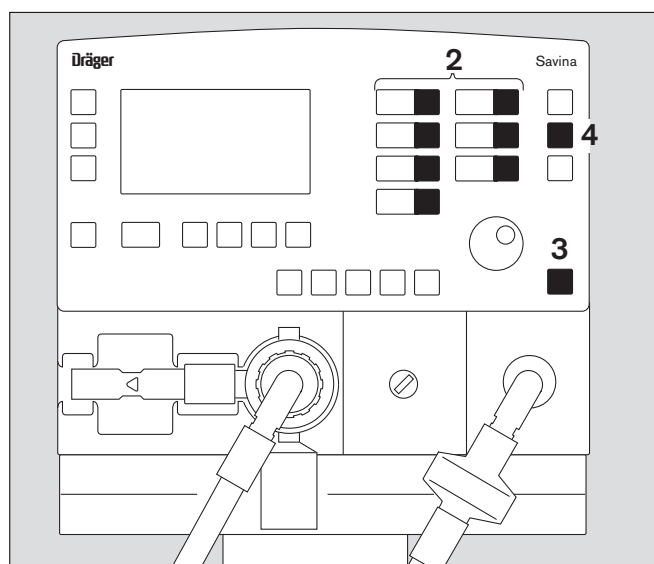
To adjust ventilation parameters:

Either

- 2 Change ventilation parameters after Savina has started ventilation

or

- 3 Press »Stand by« key to set Savina to standby.
- 4 Press »Alarm Reset« key to confirm.
- 2 Change ventilation parameters and
- 3 press »Stand by« key to return to ventilation.



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Setting Ventilation Modes

Setting ventilation parameters

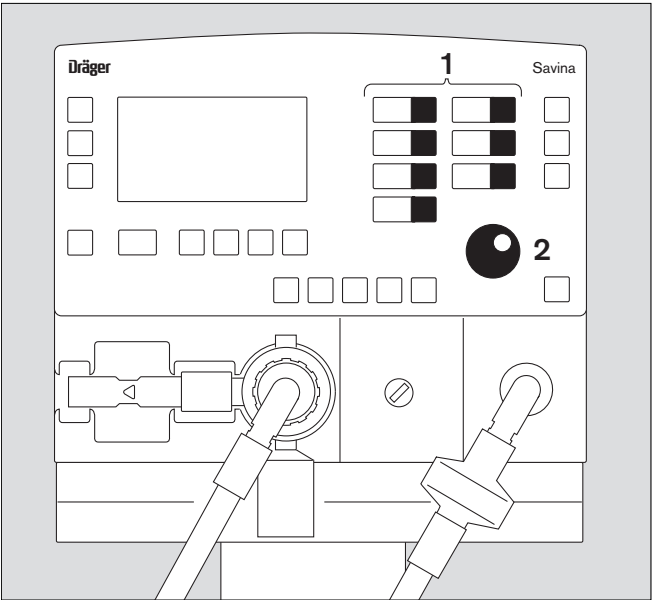
- 1 Press the respective ventilation mode key.
The yellow LED in the key will light up.
- 2 Set desired value by turning the dial knob.
Press dial knob to confirm settings.
The yellow LED in the key will go out.

If a setting exceeds the standard adjustment range, the value in the parameter key display will start flashing, indicating that confirmation is required.

- Press dial knob to confirm values outside the standard range.
- Turn dial knob to set value.
- Press dial knob to confirm.

Parameter settings for the active ventilation mode do not go into effect until confirmed.

If you fail to confirm new settings within 15 seconds, the previous settings simply will remain in effect.



Settings outside the standard range

Certain ventilation parameter settings are initially limited by Savina to not exceed certain threshold values. Values exceeding the threshold can only be set after confirmation by pressing the dial knob (see above).

Parameter	Threshold	Range
P _{insp}	↑ 50 cmH ₂ O	1 to 99 cmH ₂ O
P _{max}	↑ 50 cmH ₂ O	0 to 99 cmH ₂ O
PEEP	↑ 20 cmH ₂ O	0 to 35 cmH ₂ O
ΔP _{supp.}		0 to 35 cmH ₂ O
ΔP _{supp.} +PEEP	↑ 30 cmH ₂ O	
ΔP _{supp.} +PEEP	↑ 50 cmH ₂ O	
Δ Sigh		0 to 35 cmH ₂ O
Δ Sigh+PEEP	↑ 20 cmH ₂ O	
FlowAcc	↓ 20 cmH ₂ O/s	5 to 200 cmH ₂ O/s
Rate (f), T _{insp} *	↑ I:E > 1:1 ↓ I:E < 1:3	2 to 80 bpm 0.2 to 10 s

* Limitation of rate (f) and T_{insp} is determined by I:E ratio.

NOTE: Confirmation is not necessary when settings are reduced to fall within the normal range again.

To activate a ventilation mode

- 1 Hold down the key for the ventilation mode for approximately 3 seconds,
- or
- 1 press the key for the ventilation mode briefly, and
- 3 press dial knob to confirm.

The new ventilation mode selected is now in effect.
Ventilation always starts with the last settings.

Pre-setting parameters for another ventilation mode

- 1 Press key for the new ventilation mode briefly.
The yellow LED will start blinking.
- 2 In the block of parameter keys, the LEDs for any additional parameters required for the new ventilation mode will start blinking.

NOTE: Parameter keys continuously lit at this time indicate ventilation parameters that are operative in the active ventilation mode. Any change and confirmation of these parameters will immediately affect the active ventilation mode.

- 2 Press key of parameter to be set, its LED will then be lit continuously.
- 3 Turn dial knob to set the desired value.
Press dial knob to confirm value.
The yellow LED for that parameter key will go out.
- 3 To activate ventilation mode, press dial knob.

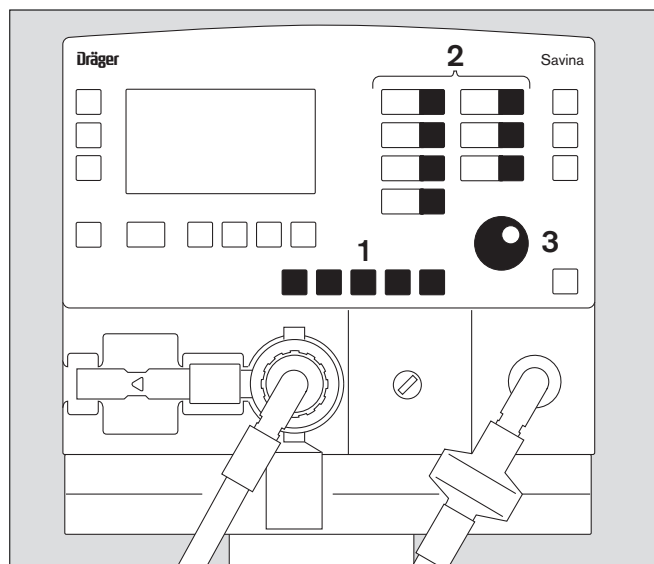
NOTE: If the setting of parameters is interrupted, Savina will not reset parameters that have been preset and confirmed.

To protect settings against modification

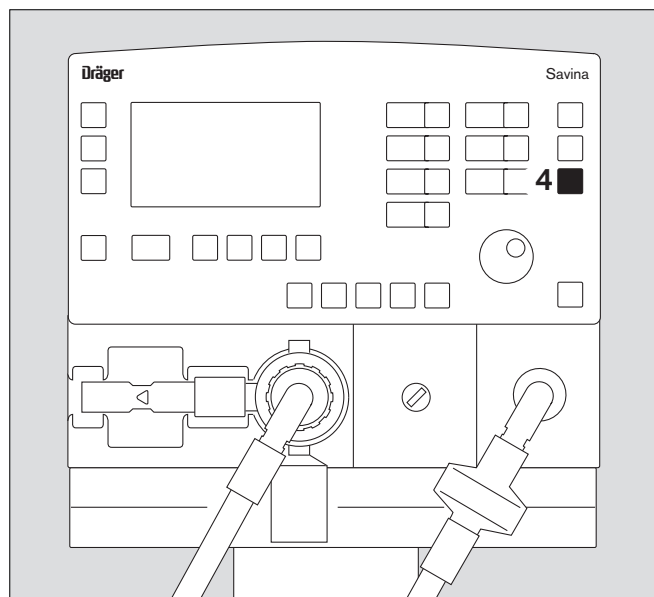
- 4 Press »  Lock« key; its yellow LED will light up.
Parameter keys, ventilation mode keys, and the screen settings are now protected against any changes.

Before setting a new value:

- 4 Press »  Lock« key again. Its yellow LED will go out.



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CMV, CMVAssist

Continuous Mandatory Ventilation

Volume-controlled ventilation with a fixed mandatory minute volume MV, set with the tidal volume VT and ventilator rate. Intended for patients unable to breathe spontaneously, (see page 142 for details).

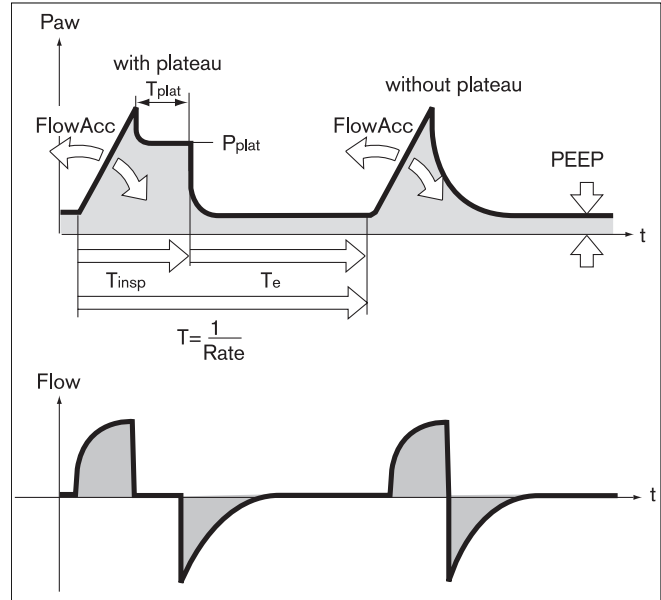
Continuous Mandatory Ventilation, Assist for patients with partial spontaneous breathing.

Set CMV with the ventilation parameter keys:

- Tidal volume »VT«,
- Inspiratory time »T_{insp}« (if plateau is "on"),
- Ventilator rate (frequency) »Rate«,
- O₂ concentration »O₂«,
- Positive end-expiratory pressure »PEEP«.

For a PEEP setting above 0, airway pressure will always remain positive (Continuous Positive Pressure Ventilation, CPPV).

CMV may be supplemented with the following ventilation mode extensions and parameters:



P_{max} pressure limit

Pressure peaks in CMV and CMVAssist can be avoided by setting a pressure limit. In this fashion, the PLV ventilation mode is implemented. (For Pressure Limited Ventilation, see page 142).

To set the pressure limit P_{max}:

- Switch P_{max} »ON«, (see page 90). P_{max} is displayed as a dotted line. The alarm limit "P_{aw} /[^]" is displayed as a dashed line.

If AutoFlow (option) is active, P_{max} is automatically set to 5 cmH₂O below the "P_{aw} /[^]" threshold and cannot be adjusted.

If AutoFlow (option) is not active:

- Set pressure limit with »P_{insp}« key.

When setting the pressure limit, take care that the required tidal volume VT is still delivered. Otherwise Savina will display the message:

!! Tidal volume low

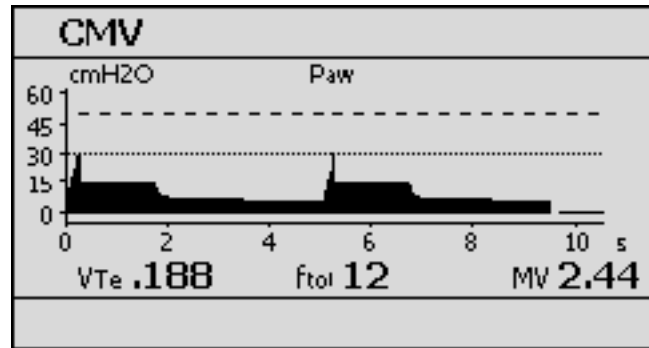
If this happens:

- Increase pressure limit
- or
- increase inspiratory time »T_{insp}«
- or
- increase **FlowAcc**.

This setting can be made on-screen:

Adjust flow delivery by setting of "Flow Acceleration"

»FlowAcc« on screen page »Settings 1/1«, see page 59.

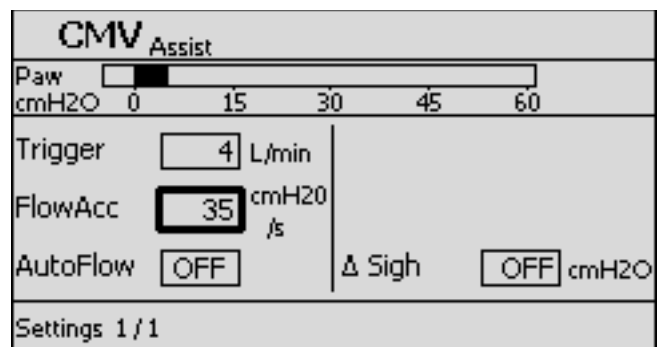


Flow Acceleration FlowAcc

By setting the FlowAcc, the pressure and flow increase at the start of inspiration can be changed.

To set FlowAcc:

- Press »**Settings** ▢▢« key, screen page »**Settings 1/1**« appears.
- Turn dial knob to select value for »**FlowAcc**« on screen, press dial knob to confirm.
- Turn dial knob to set value.
Setting range: 5 to 200 cmH₂O/s
FlowAcc high: steep pressure and flow increase
- Press dial knob to confirm setting.
- A recommended startup setting for FlowAcc is 35 cmH₂O/s.



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CMV can be extended using the following ventilation parameters:

- Trigger
- Sigh
- AutoFlow (available option)

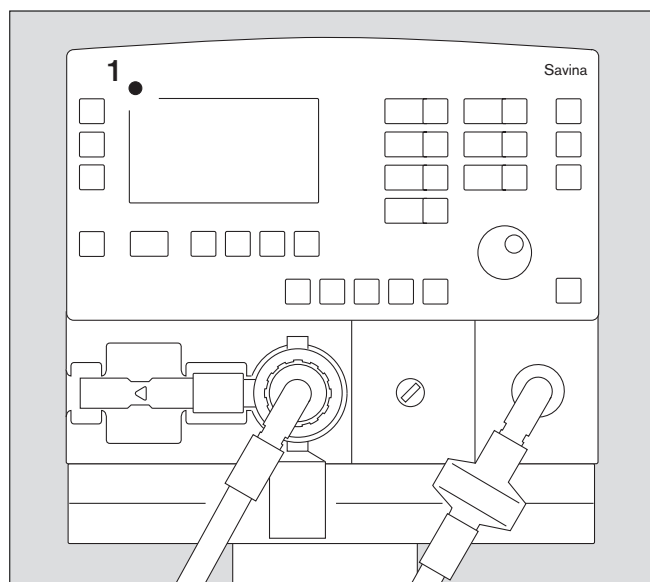
Trigger (CMVAssist)

Used to synchronize mandatory ventilator breaths with a patient's spontaneous breathing efforts. The actual breath rate may be higher than the set ventilator rate.

- 1 The green LED will light up whenever Savina has detected a spontaneous breathing effort.

The trigger may be switched off if no synchronization with a patient's spontaneous breathing is expected or desired. To set the trigger, see page 60.

NOTE: For the purpose of trigger detection Savina compensates leaks up to a leak flow of 10 L/min. Please refer to "Automatic Leak Compensation" on page 149.



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Operation

CMV, CMVAssist

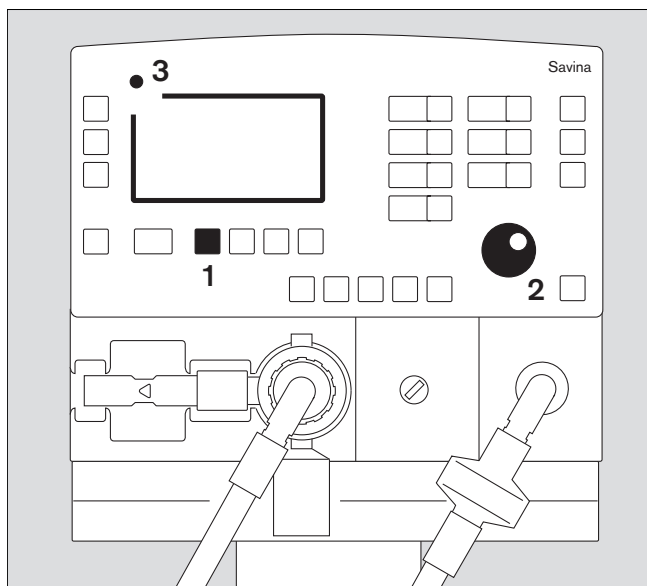
Activating/setting the trigger

- 1 Press »Settings $\triangleright \triangleright$ « key.
- 2 Press dial knob to release »Trigger« for setting.
The value is now highlighted (light on a dark background).
- 2 Turn dial knob to set value:
Low value = high sensitivity
Press dial knob to confirm.

On screen, the ventilation mode **CMVAssist** is now displayed.

- 3 The green LED will light up whenever Savina has detected a spontaneous breathing effort.

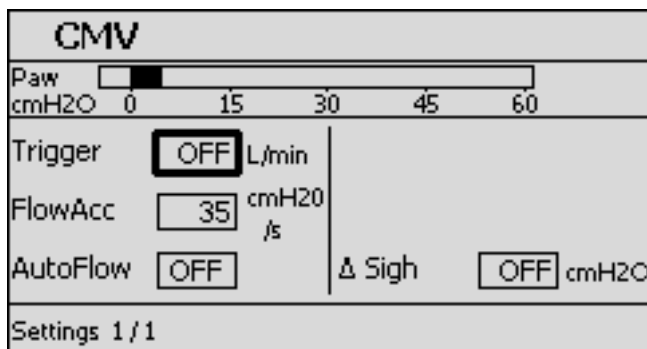
NOTE: When switching from CMV (no assist) to SIMV, PCV+, or CPAP/PS, the last trigger sensitivity setting used will be in effect.



To switch trigger off:

- Set a value less than 1. Display in the trigger field: OFF
- 2 Press dial knob to confirm.

On the screen, CMV is now showing as the ventilation mode.



Sigh

Used to prevent atelectasis.

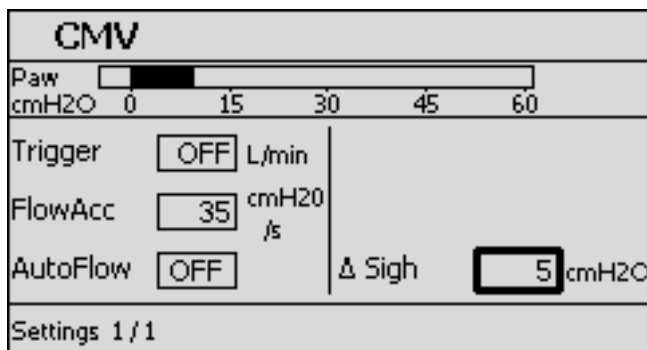
As a preventive measure against atelectasis sigh breaths may be set in the form of an intermittent PEEP.

Activating the sigh function will increase the end-expiratory pressure by the set intermittent PEEP for 2 ventilator breaths every 3 minutes.

Activating/configuring sigh breaths

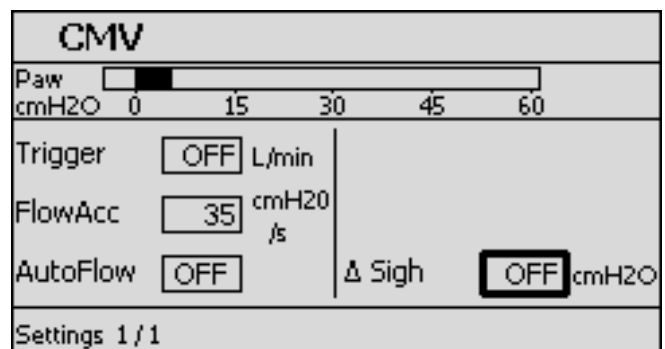
- Press »Settings $\triangleright \triangleright$ « key.
- Turn dial knob to select the item »Δ Sigh« on screen.
- Press dial knob to release »Δ Sigh« for setting.
The field appears bright against a dark background.
- Turn dial knob to set a value between 1 and 35 cmH2O.
Press dial knob to confirm.

This value of sigh pressure is added to the set PEEP.



Deactivating the sigh

- Set a value less than 1. "OFF" appears in the display. The sigh function is deactivated.

**AutoFlow® (available option)**

Automatic optimization of the inspiratory flow.

With AutoFlow^{*}, inspiratory flow is decelerated and controlled in such a way that the set tidal volume VT is delivered at a minimum airway pressure for a given patient lung compliance while avoiding pressure peaks.

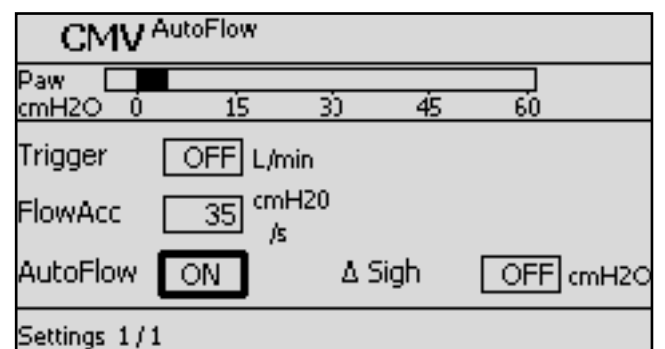
Savina supplies additional inspiratory flow during spontaneous inspirations – limited by the alarm threshold $V_{Ti} \sqrt{f}$.

The patient can also exhale during the inspiratory plateau phase.

Inspiratory pressure is limited by the alarm threshold for Paw $\sqrt{f}$.

To switch AutoFlow ON and OFF

- Press »Settings ▹▹« key.
 - Turn dial knob to select item »AutoFlow« on screen.
 - Press dial knob to release »AutoFlow« for setting.
 - Turn dial knob to set »AutoFlow ON«.
- Press dial knob to confirm.



To set alarm limits, see page 67.

* For a detailed description of AutoFlow, see page 144.

SIMV, SIMV / PS

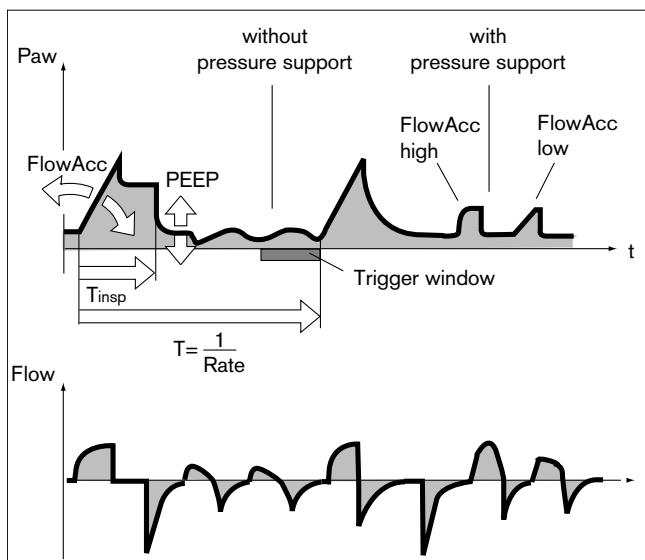
Synchronized Intermittent Mandatory Ventilation *
Pressure Support **

Fixed mandatory minute volume MV set with tidal volume V_T and ventilator rate (frequency). Between mandatory ventilator breaths, the patient can breathe spontaneously, thereby contributing to the minute volume. Spontaneous breathing can be augmented with Pressure Support.

Used for patients with insufficient spontaneous breathing or for patients being weaned from artificial ventilation by stepwise reducing the mandatory portion of the total minute volume.

Set SIMV with the following ventilation parameters:

- Tidal volume »**VT**«,
- Inspiratory time »**T_{insp}**«,
- Ventilator rate (frequency) »**Rate**«,
- O₂ concentration »**O₂**«,
- Positive end-expiratory pressure »**PEEP**«.



The following parameters are set on screen:

- Sensitivity »**Trigger**« (for synchronizing mandatory ventilator breaths) on screen page »**Settings 1/1**«, see page 60.
- Flow delivery, controlled by parameter "Flow Acceleration" »**FlowAcc**« on screen page »**Settings 1/1**«.
- AutoFlow (available option) ON/OFF

SIMV AutoFlow PS	
Paw	cmH ₂ O 0 15 30 45 60 A
Trigger	4 L/min
FlowAcc	35 cmH ₂ O /s
AutoFlow	ON
VTApnea	500 mL
fApnea	12 bpm
Settings 1/1	

Pressure limit P_{max}

Pressure peaks can be avoided by setting a pressure limit. In this fashion, the PLV ventilation mode is implemented.

To set the pressure limit P_{max} , see page 58.

For further details on Pressure Limited Ventilation, see page 142.

Additional ventilation mode extensions

- Pressure support »**ΔP_{supp.} above PEEP**«
- Apnea ventilation
(For setting apnea ventilation, see page 65.)

* For a detailed description of SIMV, see page 146.

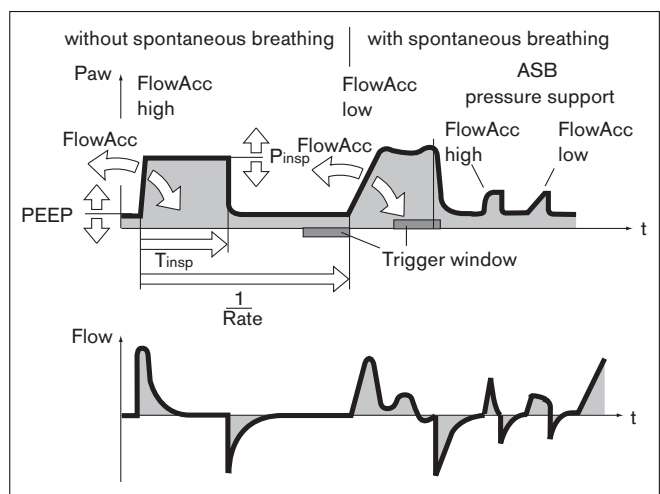
** For a detailed description of P_{Supp}, see page 147.

PCV+ (BIPAP), PCV+ / PS (BIPAP/PS)**(Available Option)****Biphasic Positive Airway Pressure
Pressure Support**

Pressure-controlled ventilation combined with free spontaneous breathing during the complete breathing cycle, supported by adjustable additional pressure at CPAP level. The mandatory portion of the total minute volume MV is set with parameters inspiratory pressure P_{insp} , PEEP, and ventilator rate (frequency).

Adaptable to a wide range of patients, from those unable to breathe spontaneously at all to those breathing spontaneously before extubation. Suitable for weaning patients from artificial ventilation by progressively reducing the mandatory portion of minute ventilation MV and by reducing pressure support ΔP_{supp} above PEEP.

For details refer to "Pressure support" on page 147.



Set PCV+ pattern with the ventilation parameters:

- Inspiratory time »**Tinsp**«,
- Ventilator rate (frequency) »**Rate**«,
- O₂ concentration »**O₂**«,
- Inspiratory pressure »**Pinsp**«,
- Positive end-expiratory pressure »**PEEP**«.

The following parameters are set on screen:

- Sensitivity »**Trigger**« (for synchronization with spontaneous breathing)
To set the trigger, see page 60.
- Flow acceleration »**FlowAcc**«,
set on screen page »**Settings 1/1**«.
The flow acceleration setting is in effect for both PCV+ bi-level breaths and pressure support
» **ΔP_{supp} above PEEP**«.

PCV+ may also be supplemented with the following ventilation mode extensions and parameters:

- Pressure support
» **ΔP_{supp} above PEEP**« (PCV+ / P_{supp}.)
- Apnea ventilation
To set apnea ventilation, see page 65.

To set alarm limits, see page 67.

CPAP, CPAP / PS

Continuous Positive Airway Pressure Pressure Support

Used for patients with adequate spontaneous breathing.

Spontaneous breathing at an elevated pressure level, to increase a patient's functional residual capacity FRC. Spontaneous breathing can be assisted with additional pressure support.

Set CPAP with the following ventilation parameters:

- O₂ concentration »**O₂**«
- Positive end-expiratory pressure »**PEEP**«

Additionally, for CPAP/PS:

- Pressure support »**ΔPsupp. above PEEP**«

The following parameters are set on screen:

- Flow acceleration »**FlowAcc**« for pressure support PSupp. on screen page »**Settings 1/1**«
- Sensitivity »**Trigger**« (for synchronizing spontaneous breathing efforts with pressure support) on screen page »**Settings 1/1**«.

CPAP, CPAP/PS may be supplemented with the following ventilation mode extensions and parameters:

- Trigger
By setting a trigger sensitivity, the assisting ventilator breaths are synchronized with the patient's own spontaneous breathing efforts.
For activating/setting a trigger, see page 60.
- Apnea ventilation
To set apnea ventilation, see page 65.

To set alarm limits, see page 67.

Apnea Ventilation

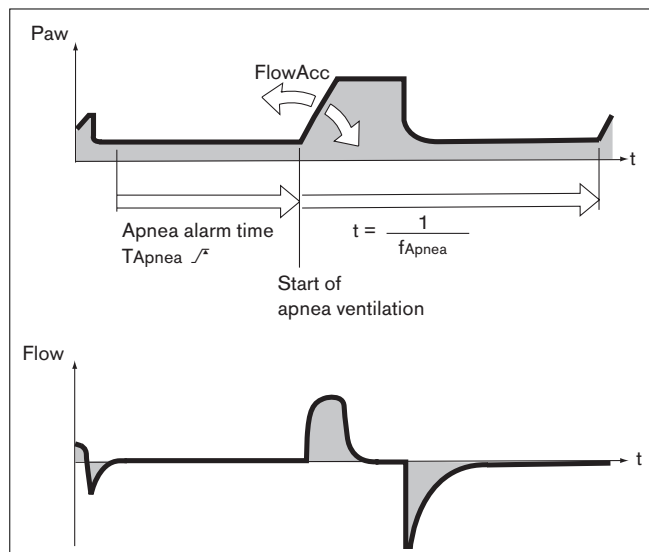
Performs automatic switchover to volume-controlled mandatory ventilation if the patient stops breathing. Apnea ventilation may be activated in the following ventilation modes:

- SIMV
- SIMV/PS
- SIMV/PS/AutoFlow (option)
- SIMV/AutoFlow (option)
- CPAP
- CPAP/PS
- PCV+ (option)
- PCV+/PS (option)

If the patient stops breathing, Savina activates an alarm after the set alarm time (T_{Apnea} ) and starts volume-controlled mandatory ventilation. Apnea ventilation employs the mode SIMV with the following parameter settings:

- tidal volume »**VT_{Apnea}**«,
- ventilator rate (frequency) »**f_{Apnea}**«,
- I:E ratio of 1:2 (if plateau is active; otherwise I:E ratio is determined by the parameter »**FlowAcc**«).

The patient can breathe spontaneously during apnea ventilation at any time. Spontaneous breaths during expiration can be assisted with pressure support. The parameters flow acceleration »**FlowAcc**«, pressure support »**ΔP_{supp.} above PEEP**«, »**Trigger**«, and AutoFlow (option) are active.



To set apnea ventilation

- Press »**Settings**  key to display screen page »**Settings 1/1**«.

With apnea ventilation switched on, the fields »**VT_{Apnea}**« and »**f_{Apnea}**« are visible.

On the main screen page, "A" = "Apnea Ventilation Standby" appears on the right of the main screen page.

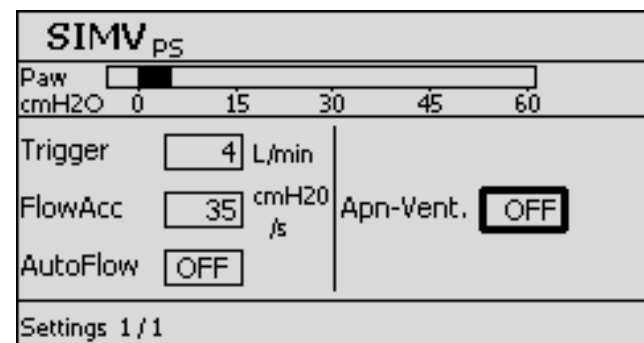
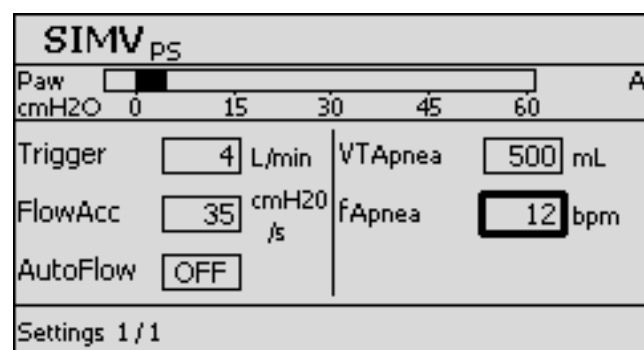
If apnea ventilation is switched off, »**Apn.-Vent. OFF**« will be showing in the display instead of the »**f_{Apnea}**« line,

To switch apnea ventilation on:

- Turn dial knob to select screen field »**Apn.-Vent. OFF**«. Press dial knob to activate apnea ventilation.
- Turn dial knob to select a value of at least 2 bpm, the fields »**VT_{Apnea}**« and »**f_{Apnea}**« will become visible.
- Select screen fields by turning dial knob again, press dial knob to activate.
- Turn dial knob to adjust value, press dial knob to confirm.

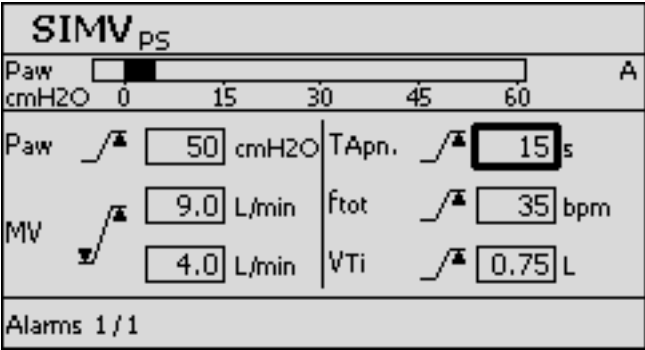
To deactivate apnea ventilation:

- Turn dial knob to select a value lower than 2 in the field »**f_{Apnea}**«, and press dial knob to confirm.



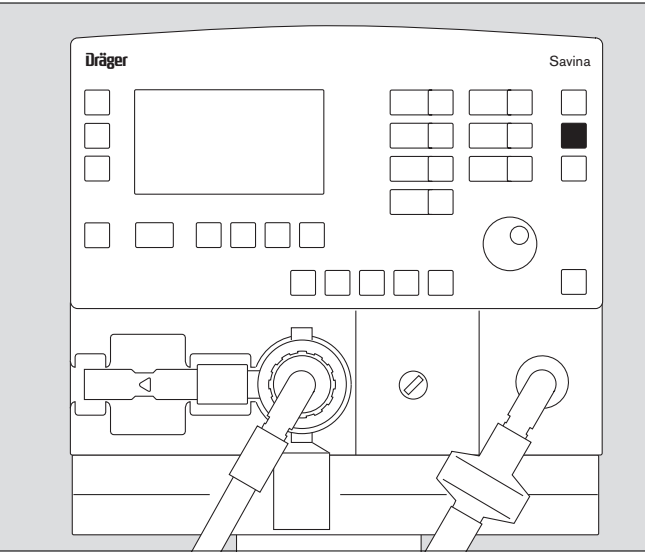
Setting apnea delay time T_{Apnea} in the "Alarms" screen page

- Press »Alarms « key to display screen page »Alarms 1/1«
Turn dial knob to select field »TApn. «, press dial knob to activate.
- Turn control knob to adjust value, press dial knob to confirm.



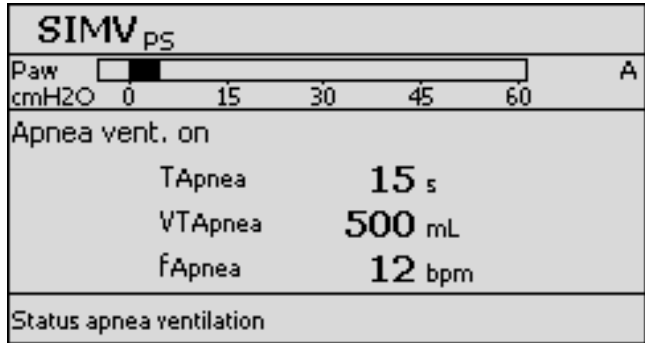
To end apnea ventilation:

- Press »Alarm Reset« key.
The ventilator will continue to ventilate in the original ventilation mode with the associated ventilation parameters set for that mode.



When ventilator settings are adjusted, the status of apnea ventilation is displayed on a special info screen page for 6 seconds in all those cases where apnea ventilation would be possible in principle:

- when switching between ventilation modes,
- when switching Savina on,
- when, by reducing the ventilator frequency, the cycle time becomes longer than the current value of T_{Apnea} .



To set alarm limits, see page 67.

Setting Alarm Limits

- Press »Alarms $\triangleright\triangleright$ « key.

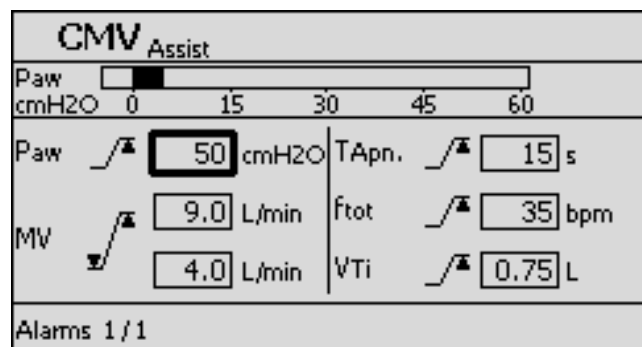
Example display: screen page »Alarms 1/1«

This page displays all alarm limits that can be set.

$\nabla/\wedge$ = lower alarm limit

$\wedge/\nabla$ = upper alarm limit

Alarm	Setting Range
Paw $\wedge/\nabla$	10 to 100 cmH ₂ O
MV $\wedge/\nabla$	2.0 to 41 L/min
MV $\nabla/\wedge$	0.5 to 40 L/min
TApnea $\wedge/\nabla$	15 to 60 sec
ftot $\wedge/\nabla$	10 to 120 bpm
VTi $\wedge/\nabla$	0.06 to 4 L



Example: Setting the upper alarm limit for Paw.

- Turn dial knob to select field »Paw $\wedge/\nabla$ « on screen, press dial knob to activate for setting.
- Turn dial knob to adjust value, press dial knob to confirm.

On the main page, the adjusted »Paw $\wedge/\nabla$ « value will be displayed as a dashed line.

For airway pressure Paw, the lower alarm limit does not have to be set, because it is automatically linked to the PEEP setting.

For the O₂ concentration, no alarm limits have to be set, because they are automatically linked to the setting of O₂ concentration:

Lower alarm limit:

Setpoint -4 Vol.% (for setpoints up to 60 Vol.%)

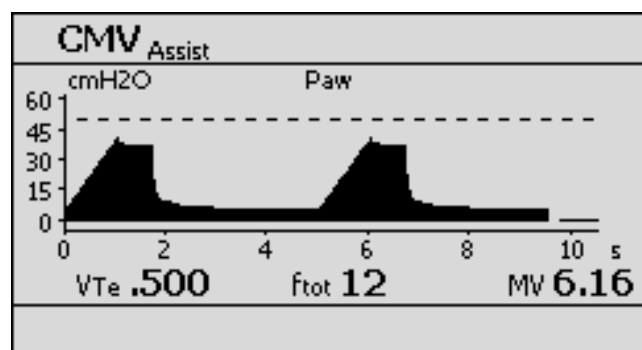
Setpoint -6 Vol.% (for setpoints from 60 to 100 Vol.%)

Upper alarm limit:

Setpoint +4 Vol.% (for setpoints up to 60 Vol.%)

Setpoint +6 Vol.% (for setpoints from 60 to 100 Vol.%)

A separate screen page »Alarms 2/2« appears for the optional mode »Mask/NIV«. See page 74.



Operation

In the Event of an Alarm

Alarm Categories

In the Event of an Alarm

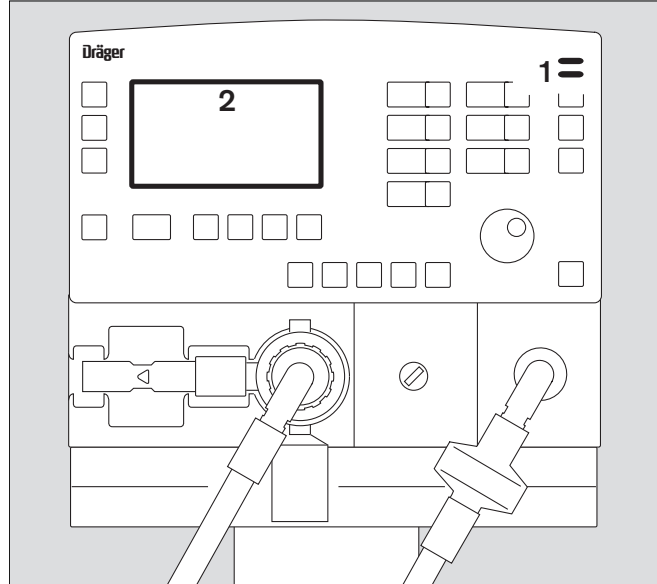
- 1 The red or yellow LED will begin to flash.
- 2 An alarm message will be displayed in the right-hand corner of the top line of the screen.

Savina assesses the alarm message according to its priority, marks the text with exclamation marks corresponding to the alarm level and generates a different alarm tone sequence for each level.

WARNING !

Warning or Caution level audible alarms require immediate operator attention to avert or to prevent development of situations with the possibility of patient injury.

- !!! = Warning (red LED flashes)
- !! = Caution (yellow LED flashes)
- ! = Advisory (yellow LED lights up and remains continuously lit)



NOTE: Savina will display a message for operator guidance in the information line when certain alarm messages have occurred.

Alarm Categories

Warning

Top priority message

- 1 Red LED flashes.
- Warning messages are marked with three (3) exclamation marks.
Example: **!!! Apnea**

Savina generates a five-tone sequence that sounds twice and is repeated every 7.5 seconds as the warning-level audible alarm.

Caution

Medium priority message

- 1 Yellow LED flashes.
- Caution messages are marked with two (2) exclamation marks.
Example: **!! Check settings**

Savina generates a 3-tone sequence that is repeated every 20 seconds as the caution-level audible alarm.

Advisory

Low priority message

- 1 Yellow LED lights up and remains lit.
Advisory messages are marked with one exclamation mark.
Example: ! **Flow monitoring inactive**

Savina generates the corresponding audible alarm as a two-tone sequence that sounds only once.

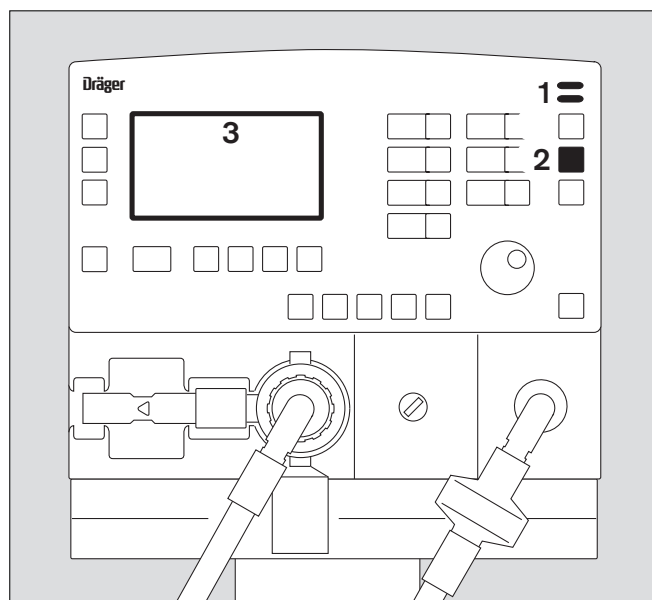
To remedy any faults, please refer to the "Troubleshooting" section starting on page 112.

Once a fault has been remedied

The audible alarm will be switched off.
Caution (!!) and Advisory (!) messages will disappear automatically from the screen.

Warning (!!!) messages remain displayed black on white on screen and must be acknowledged:

- 2 Press »Alarm Reset« key.
- 3 The message is erased from the screen.

**Silencing Audible Alarms**

for a maximum of 2 minutes:

- 1 Press »Alarm Silence« key. Its yellow indicator LED will light up and the alarm tone will be muted for about 2 minutes. If the cause of the alarm has not been remedied, the audible alarm will start again after the 2 minute time period.

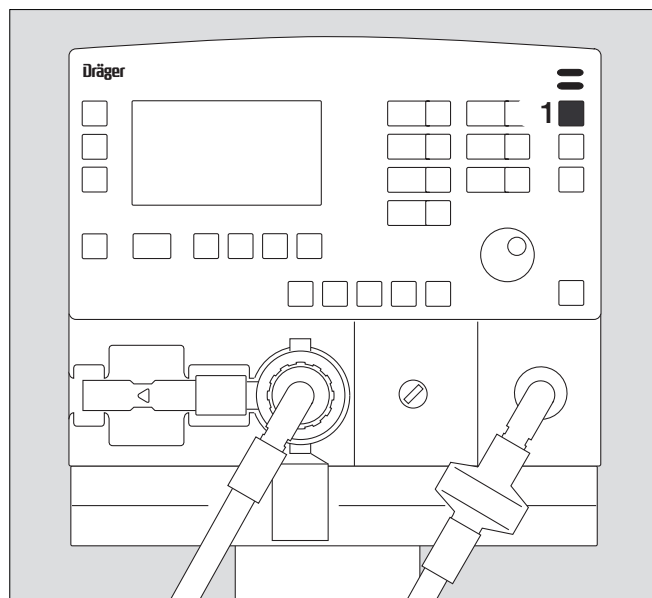
WARNING !

The alarm silence key is intended to provide a way of muting audible alarms while corrective action is taken. The operator of the ventilator must still assume responsibility for proper ventilation and patient safety in the event of an alarm. Failure to identify and correct alarm situations may result in patient injury.

If you wish to rearm the audible alarm before the end of the 2-minute silencing period:

- 1 Press »Alarm Silence« key again. The yellow LED will now go out. The message remains on the screen.

If a higher priority alarm occurs while the audible alarm is muted, the audible alarm will sound only once.



Operation

Displaying Waveforms and Measured Values
Displaying Measured Values

Displaying Waveforms and Measured Values

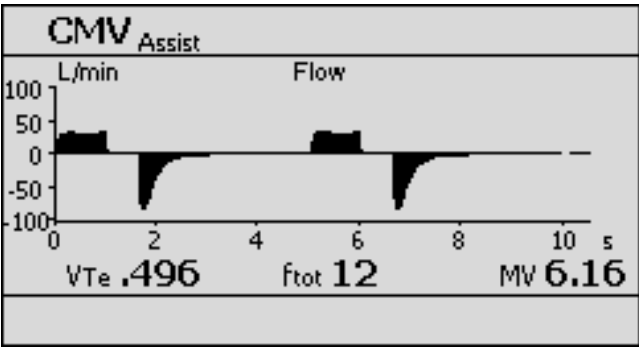
On the main page
airway pressure waveform or flow waveform and three relevant
measured values are displayed

To change the waveform display

- Press »Waveforms « key.

Example: flow waveform

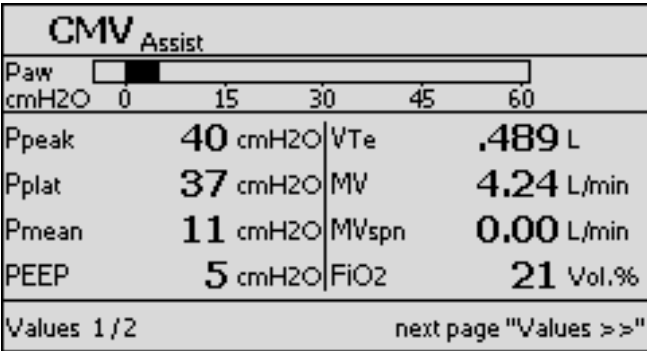
The combination of measured values to be displayed in the
measured values screen field is configurable, see page 87.



072 37409

Displaying Measured Values

- Press »Values « key. The screen page
»Values 1/2« appears, or, in »Mask/NIV« mode
»Values 1/3«.
Airway pressure is displayed as a bar graph.
The other measured values are displayed numerically.

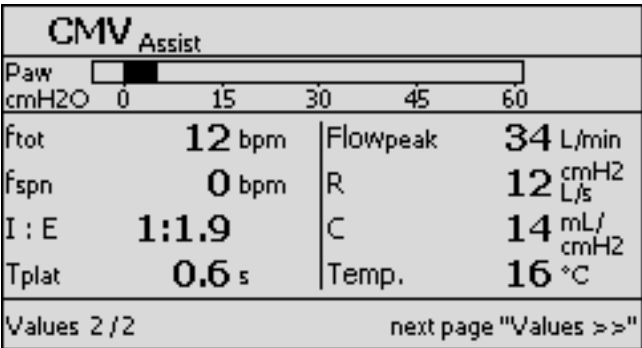


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Displaying other measured values

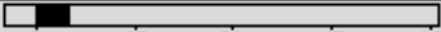
- Press »Values « key again. The screen page
»Values 2/2« appears, or, in »Mask/NIV« mode,
»Values 2/3«.

When ventilating without plateau, the value of T_{insp} will be
showing instead of T_{plat}.



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While in »Mask/NIV« mode, another page, »Values 3/3« can be displayed. For reference, see page 150.

CMV Assist			
Paw			
cmH2O	0	15	30 45 60
Ftot	10 bpm	VTpat	.487 L
fspn	0 bpm	MV	3.87 L/min
		MVspn	0.00 L/min
PEEP	5 cmH2O	MVleak	35 %
Values 3 / 3		next page "Values >>"	

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NIV – Non-invasive Ventilation, Mask Ventilation (Available Option)

Installing the NIV option

WARNING !

Installation of the Savina NIV option should only be performed by DraegerService or factory trained and authorized service personnel.

Using NIV

For a detailed description of NIV, see page 150.

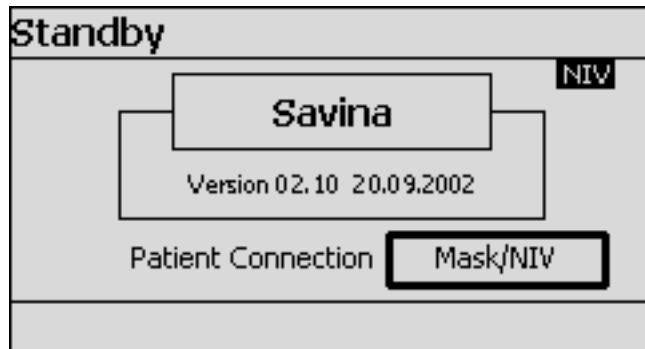
WARNING !

Precautions when using mask ventilation.

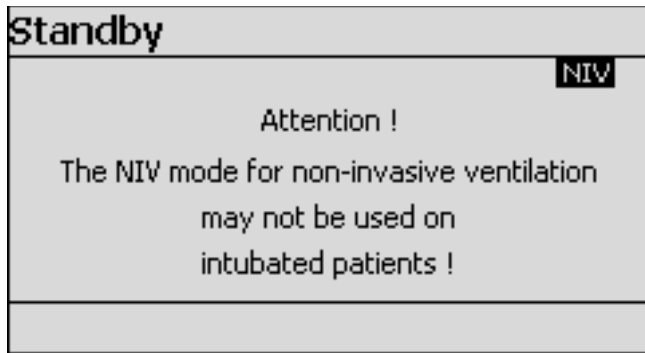
- Never ventilate an intubated patient in »Mask/NIV« mode.
- In Mask/NIV« mode, the alarm system is adapted to mask ventilation. Make sure that only patients are ventilated in this mode who can breathe sufficiently on their own, especially when alarms have been manually disabled.
- When masks are used, dead space increases.
- Always follow the mask manufacturer's directions to properly deal with the increased dead space caused by the mask.
- Avoid high airway pressures. Risk of aspiration.
- Never operate Savina without a water trap on the expiratory valve – overcompensation for leakage might cause unintentionally high airway pressure and mis-triggering might occur.
- Always check alarm limits after changing from »Mask/NIV« to »Tube« mode.

Selecting »Mask/NIV« mode

- Press »Stand by« key for about 3 seconds to switch ventilator to standby.
- Press »Alarm Reset« key to switch off the audible alarm.
- Press dial knob to select »Patient Connection« display field.
- Press dial knob to select »Mask/NIV« field,
- Press dial knob to confirm.



The following advisory message appears briefly:



Setting the ventilation parameters

- Proceed as in »Tube« mode.

In »Mask/NIV« mode, the »T_{insp}« key provides extended functionality:

In addition to setting inspiratory time in modes of mandatory ventilation (CMV, SIMV, or PCV+), the »T_{insp}« key is also used to set the maximum duration of the pressure supported spontaneous breaths during pressure support ventilation.

- Set T_{insp} or the maximum duration of the pressure support breaths, 0.2 to max. 10 s.

Automatic leakage compensation for trigger

For improved detection of a patient trigger, Savina compensates for leaks of up to 25 L/min.
See page 149 for further details.

Automatic compensation of set tidal volume

When Savina determines the presence of a leak, it will compensate lost volume for up to 100 % of measured minute ventilation.

For further details, see page 149.

WARNING !

Never operate Savina without a water trap on the expiratory valve - overcompensation for leakage might cause unintentionally high airway pressure and false triggering might occur.

Leak compensation disabled

If the flow sensor is missing or flow monitoring has been disabled, no leak compensation will take place.

Monitoring in the »Mask/NIV« mode

In the case of very big leaks, the following alarms may be switched off to avoid artifacts:

- »MV « minute volume lower alarm limit
- »VTi « inspiratory tidal volume upper alarm limit
- »TApnea « apnea monitoring upper alarm limit

WARNING !

Only switch off alarms if the safety of the patient will not be compromised by the absence of an alarm.
The operator of the ventilator system must still assume full responsibility for proper ventilation and patient safety in all situations.

To switch an alarm off (for example MV):

Reduce »MV « until the following message appears:

MV  off?  Press and turn rotary knob

- Press dial knob to confirm.
- Continue turning the dial knob until **OFF** appears in the display.
- Press dial knob to confirm.

If an alarm limit has been switched off, an advisory message will be displayed continuously, e.g.:

! MV low Alarm off

The following warning messages will not be displayed in »Mask/NIV« mode:

- **PS >4 s**
- **Leakage**

Operation

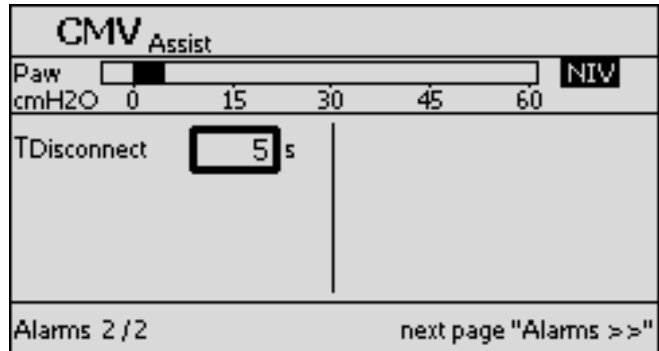
NIV – Non-invasive Ventilation, Mask Ventilation (Available Option)

Setting TDisconnect

In »Mask/NIV« mode, a delay »TDisconnect« from 0 to 60 seconds can be set for the "Airway pressure low" alarm. In the event of a disconnection, the activation of the alarm is then delayed by the time set.

The default value for the »TDisconnect« delay after activating »Mask/NIV« mode is 10 seconds.

- Press the »Alarms $\triangleright\triangleright$ « key until the screen page »Alarms 2/2« appears..
- Activate the »TDisconnect« line to set.
- Turn dial knob to set TDisconnect.
- Press dial knob to confirm.



Selecting »Tube« mode

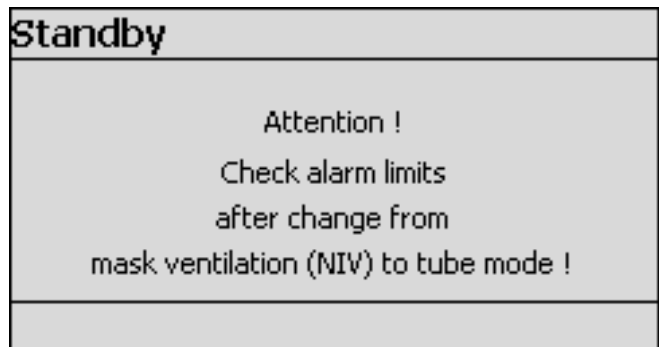
- Hold down »Standby« key for about 3 seconds to switch ventilator to standby.
- Press »Alarm Reset« key to switch off the audible alarm.
- In order to make your selection, press dial knob to activate »Patient Connection« line.
- Turn dial knob to select »Tube«.
- Press dial knob to confirm.

An advisory message to check alarm limits appears briefly.

WARNING !

Always check alarm limits after changing from »Mask/NIV« to »Tube« mode.

When switching over to »Tube« mode, Savina automatically selects the default alarm limits for the alarms previously switched off in »Mask/NIV« mode.



Special Functions

Manual inspiration

This function is accessible in all modes except CPAP spontaneous breathing without pressure support. It allows to deliver a mandatory breath with a minimal duration of T_{insp} and a maximal duration of 15 seconds. The manual inspiration may be superimposed onto an already delivered mandatory breath or it may be delivered between two automatic breaths.

The pattern of the manually started ventilator breath depends on the ventilation mode in use.

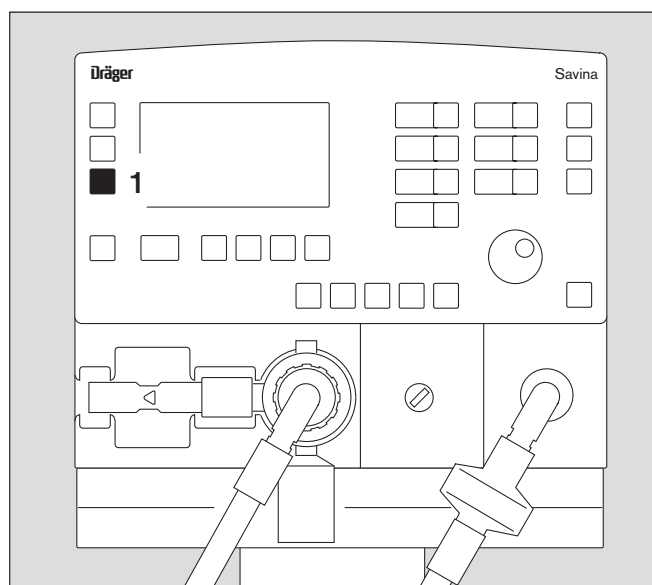
For CMV, SIMV:
volume controlled ventilator breath, defined by the »**VT**« and »**Tinsp**« settings.

For PCV+:
pressure controlled ventilator breath, defined by the »**Pinsp**« and »**Tinsp**« settings.

For CPAP/PS:
pressure-assisted ventilator breath, defined by the »**Δ Psupp. above PEEP**« setting.

- 1 Press and hold down »**Insp. hold**« key for as long as inspiration is desired.

Either an automatic ventilator breath that has just begun will be prolonged or a new ventilator breath is initiated. The manual inspiration lasts at least for T_{insp} seconds. If the »**Insp. hold**« key is pressed longer, the duration may be extended for up to a maximum of 15 seconds.



Nebulizing Pharmaceutical Aerosols

Applicable in every ventilation mode.

NOTE: Use of the nebulizer port will only be available with a connected O₂ supply between 39 and 87 psi (2.7 to 6 bar).

An inspiratory flow of 18 L/min is needed to trigger the nebulizer gas supply. Small patients, or any patient who has a low initial inspiratory flow rate will not trigger the nebulizer gas supply during the early part of the breath. Under these conditions, the nebulized drug would not be distributed well to the distal airways. For this reason, nebulizer mode is recommended for use only with adults and larger children under conditions when the nebulizer flow will be triggered during early inhalation.

Savina applies the pharmaceutical aerosol in synchrony with inspiration, i.e., only during the inspiratory flow phase, while automatically maintaining a constant minute ventilation. Savina automatically turns the nebulizer off after 30 minutes. The flow sensor will be automatically heat-cleaned and calibrated after the aerosol treatment to prevent artifacts during flow measurement.

WARNING !

Never use flammable medications (e.g. on the basis of ethanol). Fire hazard!

WARNING !

Since Savina uses pure oxygen for nebulizing pharmaceutical aerosols, an increase of the set inspiratory O₂ concentration may be caused

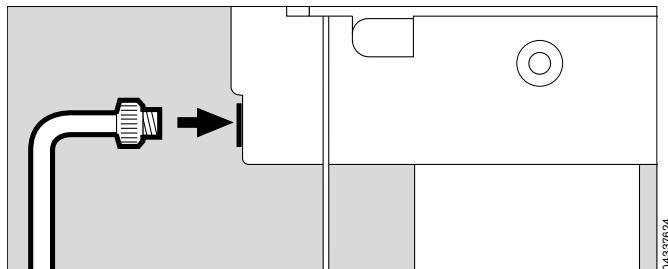
Due to the inability of Savina to measure this increase in the O₂ concentration, an incorrect O₂ reading will be displayed.

- Connect your O₂ supply of 39 to 87 psi (2.7 to 6 bar) – from the medical O₂ pipeline system or from a cylinder, to the Savina ventilator (side panel).
- Prepare the nebulizer in accordance with its accompanying Instructions for Use.

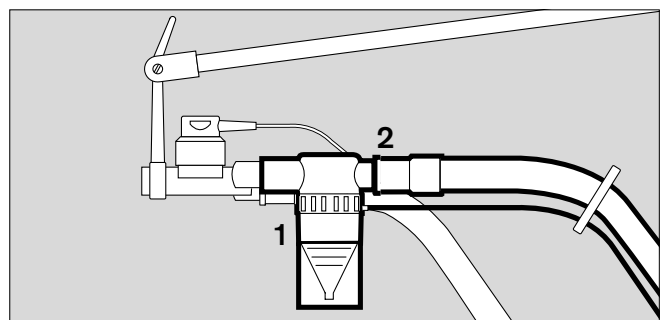
WARNING !

The integrated nebulizer function of Savina is designed for nebulizers with a nebulizing flow of 6 L/min at 29 psi (2 bar), for example nebulizer 84 12 935 (white central body).

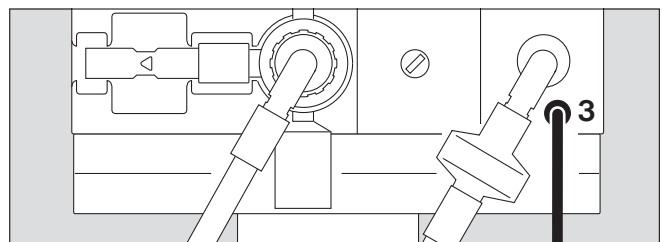
Use of other pneumatic nebulizers may result in considerable discrepancies in the minute-volume reading!



- 1 Connect nebulizer to the inspiratory side of the wye (temperature sensor side).
- 2 Connect inspiratory circuit to the nebulizer.
 - Swivel nebulizer to the vertical position.
 - Using clamps, route the nebulizer hose back to the ventilator along the patient circuit.



- 3 Connect the nebulizer hose to the small nozzle on the front of Savina.
 - Fill nebulizer in accordance with its accompanying instructions for use.



WARNING!

Do not use a heat/moisture exchanger (HME) while nebulizing pharmaceutical aerosols.
Risk of increased breathing resistance.

- 4 Hold down »  **Nebul.**« key, until the yellow light is illuminated.

On-screen advisory message:

! Nebulizer on

The nebulizer is in operation for 30 minutes; nebulization occurs only in the inspiratory flow phase.

If nebulization needs to be stopped prematurely:

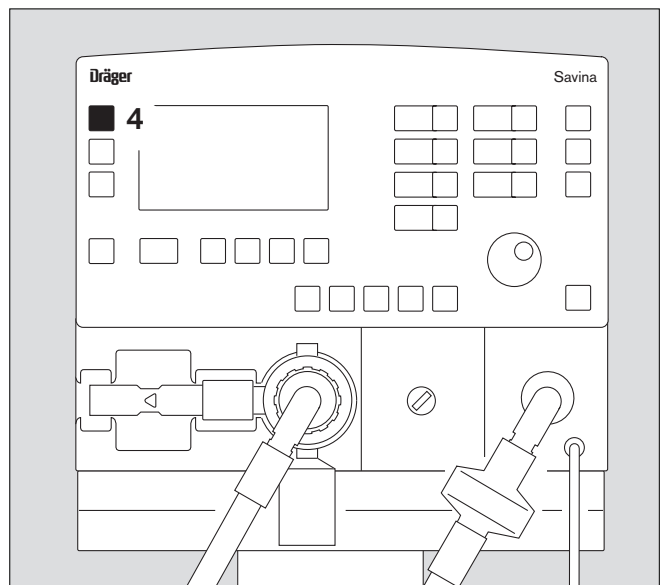
- 4 Press »  **Nebul.**« key again. The yellow light goes out, the nebulizer is switched off.

Savina will then automatically heat-clean and calibrate the flow sensor.

On-screen information:

Flow calibration

- Remove any leftover medication from the nebulizer.
- Follow nebulizer instructions for use for this procedure.



WARNING !

Consider effects of aerosols on sensors and filters!
The measuring function of the flow sensor may be impaired.
The flow resistance of filters is liable to increase and may impair ventilation.
Do not put a bacteria filter on the nebulizer outlet when in use!

Operation

Pre-/Post-Oxygenation for Bronchial Suction

Pre-/Post-Oxygenation for Bronchial Suction

NOTE: This feature will only be available with a connected O₂ supply between 2.7 to 6 bar (39 to 87 psi).

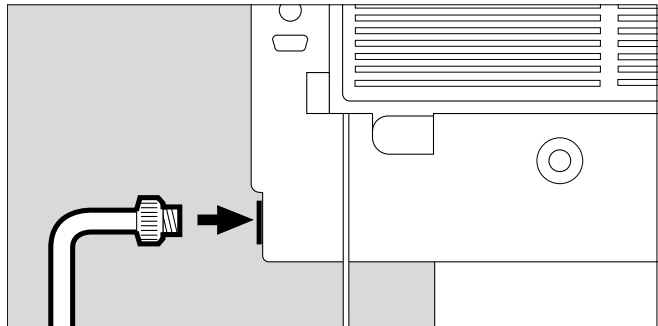
To prevent hypoxia during bronchial suction, Savina is provided with an oxygenation program to be used when removing of secretions.

After the program has started, Savina ventilates in the selected ventilation mode for up to 180 seconds with 100 Vol.% oxygen as a pre-oxygenation phase.

When the ventilator is disconnected for suction, Savina automatically interrupts ventilation. During the suction phase, the alarms "!!! Apnea", "!!! Fail to cycle", "!!! Airway pressure low", and "!!! MV low" are suppressed so that the suction routine is not disrupted.

After suction and the automatically recognized reconnection, Savina ventilates 120 seconds with 100 Vol.% O₂. During suction, and for two minutes afterwards, the lower alarm limits for both minute ventilation and airway pressure alarms are disabled.

- Connect your O₂ supply 2.7 to 6 bar (39 to 87 psi) – from the medical O₂ pipeline system or from a cylinder, to the Savina ventilator.

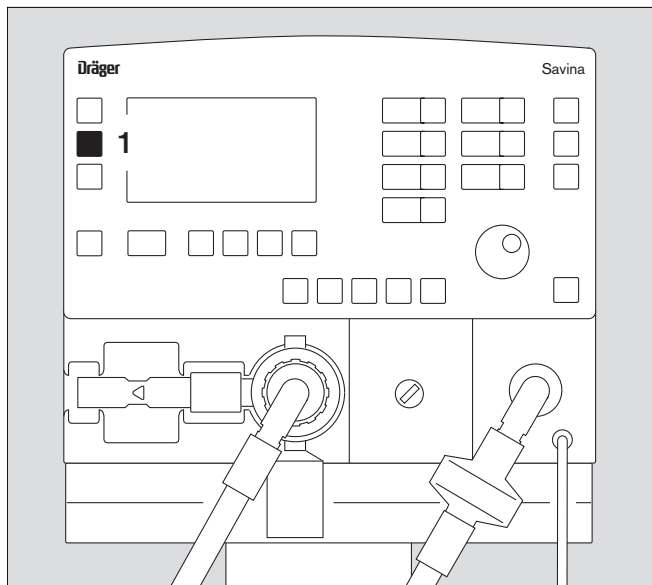


Before suction

- 1 Hold down »O₂ ↑ Suction« key until the yellow lamp lights up.
Savina now ventilates with 100 Vol.% O₂ in the set ventilation mode.
In case PEEP has not been set higher than 4 cmH₂O, an automatic setting of 4 cmH₂O will be applied.
This PEEP will enable Savina to detect any subsequent disconnection. All other ventilation parameters remain unchanged.

Message in the information line on screen:

O₂ enrichment 100 % 180 s



The time remaining for pre-oxygenation is continuously displayed on screen.

Pre-oxygenation lasts for a maximum of 180 seconds. During this time, Savina waits for a disconnection associated with the begin of suction.

NOTE: For small tidal volumes, the patient may not immediately get the displayed O₂ concentration due to the large tubing volume relative to tidal volumes. O₂ is not measured in the patient wye. Therefore, make sure to use the maximum pre-oxygenation time for small patients.

If there is no disconnection after 180 seconds, Savina will terminate the oxygenation program.

After disconnecting patient for suction

During the period of disconnection, Savina supplies a minimal flow of 100 Vol.% O₂ in order to automatically detect the end of the disconnection phase. The remaining time available for suction is continuously counted down on screen in the information line, (example):

Execute suction and reconnect 120 s

If suction is ended and the system is reconnected within the displayed time, Savina begins post-oxygenation.

After reconnection

After reconnection has taken place, Savina ventilates again in the set ventilation mode. However, for the purpose of post-oxygenation, 100 Vol.% O₂ are used for another 120 seconds.

Message in the information line on screen:

Final O₂ enrichment 100 % 120 s

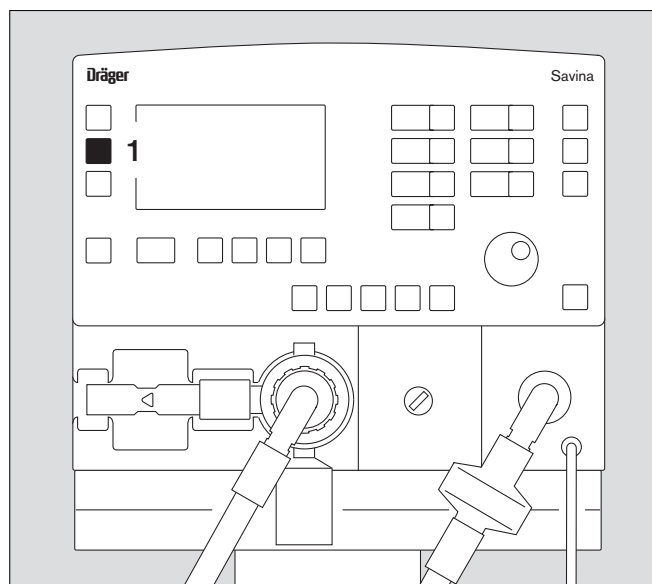
The remaining time is continuously counted down on screen.

In case the oxygenation program has to be interrupted:

- 1 Press the »O₂ ↑ Suction« key again

Automatic discontinuation of the oxygenation program

If no reconnection has followed after 120 seconds, Savina stops the oxygenation program. All alarms are immediately reactivated. Savina immediately continues ventilating in the set ventilation mode.



Calibrations

Calibration / zeroing values are saved and remain stored even when the ventilator is switched off.

Automatic calibration of the pressure sensors

The pressure sensors for measuring airway pressure are calibrated automatically.

Automatic calibration of the flow sensor

The flow sensor will be automatically calibrated under the following circumstances:

- when the ventilator is switched on
- every 24 hours during operation
- after changing the flow sensor
- after using the pneumatic nebulizer
- after bronchial suction
- after changing the O₂ concentration

NOTE: Savina uses a full inspiratory phase for calibration. Short inspiratory times are extended to approximately one second.

Message in the information line on the screen:

Flow calibration in progress

After calibration is complete, the following message should appear in the information line:

Flow calibration ok

If the attempt at calibration was not successful, the display will show:

Flow calibration failed

The expiratory portion of the flow waveform will not be showing on screen and no measured values for V_{Te}, MV and PEEP will be displayed.

Then:

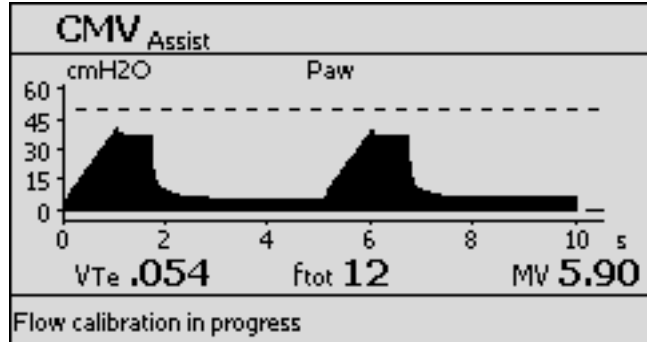
- Exchange flow sensor

NOTE: Without a usable flow measurement neither the O₂ calibration nor the pre-/post-oxygenation during bronchial suction is possible.

NOTE: Without a usable flow measurement, leaks cannot be compensated properly, which may degrade ventilation performance.

WARNING !

Always pay special attention to the success of a flow calibration. The operator of the ventilator must still assume responsibility for proper ventilation and patient safety in the event of a loss of expiratory flow monitoring. Replace a faulty flow sensor as soon as possible.



Calibrating O₂ Sensors

Savina uses one O₂ sensor for O₂ control and display of the O₂ concentration (sensor 1). A second O₂ sensor (sensor 2) is used for O₂ monitoring, verifying the measurement of sensor 1.

The O₂ sensor for O₂ control and display (sensor 1) is automatically calibrated by Savina:

- after 8 hours of operation
- when sensor 2 is calibrated
- when the O₂ sensor is replaced
- if readings from sensor 1 and 2 differ from each other by more than 2 Vol.%
- when the air pressure changes by more than 200 hPa (150 mmHg), e.g. during helicopter transports
- after a change in temperature of more than 10 °C (18 °F).

WARNING !

Always use a reliable independent O₂ supply during calibration that contains 100% O₂. In case the calibration procedure is based on a diluted oxygen source, Savina may deliver inaccurate oxygen concentrations without further notification.

During automatic calibration, the following message will appear in the information line on the screen:

O₂ calibration in progress

After calibration is complete, the following message should appear:

Calibration ok

Sensor 2 (for O₂ monitoring) has to be calibrated manually:

- once per month.
- or
- if the following alarm occurs:
!!! O₂ measurement failure

Manual calibration may be performed in any ventilation mode, see page 88.

Operation

Operation at High Ambient Temperature

In the Event of a Power Supply Failure

In the Event of a Gas Supply Failure

Operation at High Ambient Temperature

At ambient temperatures above 35 °C Savina displays an advisory message:

! Temperature high

To prevent the breathing gas from becoming too hot, Savina reduces the maximum speed of the built-in blower as the ambient temperature rises. If high inspiratory pressures are set at the same time, e.g. beyond 80 cmH₂O, the result may be that high flows, e.g. 180 L/min, can no longer be reached.

Even at slower speeds, the blower will increase the temperature of the delivered breathing gas to some extent.

To ensure that the breathing gas temperature at the Y-piece remains under 41 °C, an inspiratory hose length of not less than 1.2 m (4 foot) should be maintained as a cooling element. If the temperature sensor built into Savina reaches over 40 °C, an alarm will be activated.

!!! Temperature high

If an optional temperature sensor* is used in the patient wye, Savina will warn of breathing gas temperatures of 40 °C or higher by activating the alarm

!!! Breathing gas temp. high

In both cases, Savina continues ventilating the patient.

- Lower ambient temperature.

In the Event of a Power Supply Failure

If all external and internal power sources fail, an intermittent audible alarm sounds.

- Either immediately reconnect power supply or
- Disconnect patient and continue ventilating using a substitute ventilator.

In the Event of a Gas Supply Failure

In normal ventilation, Savina ventilates with ambient air via a turbine blower system and with O₂ from a medical gas pipeline system or from a cylinder.

In the event of O₂ failure

Savina substitutes the missing fraction of inspiratory O₂ with ambient air and generates an alarm.

* See "Ordering Information" on page 154.
Only use temperature sensors with blue leads.

Minute volume remains constant.

The inspiratory O₂ concentration FiO₂ drops to 21 Vol.%.

If the patient needs an inspiratory O₂ concentration higher than 21 Vol.%:

- Reconnect to a working O₂ supply without delay.

In the event of a blower failure

WARNING !

In the event of a failure of the turbine blower, Savina is not able to continue ventilation. Immediately continue ventilation using an independent manual ventilation device (resuscitation bag) in this case.

NOTE: Spontaneous breathing is possible at any time.

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Configuration

Setting the Screen Contrast	86
Adjusting the Volume of the Audible Alarm	87
Configuring the Measured Values Field	87
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Configuration

The following user preferences can be selected in

»**Configuration**« mode:

- Screen contrast
- Audible alarm volume
- Measured values field
- Manual calibration for O₂ sensor 2
- FiO₂ and flow monitoring ON / OFF
- Pmax ON / OFF
- Plateau ON/OFF
- Language, date and time
- MEDIBUS communication protocol
- Remote Service (option)

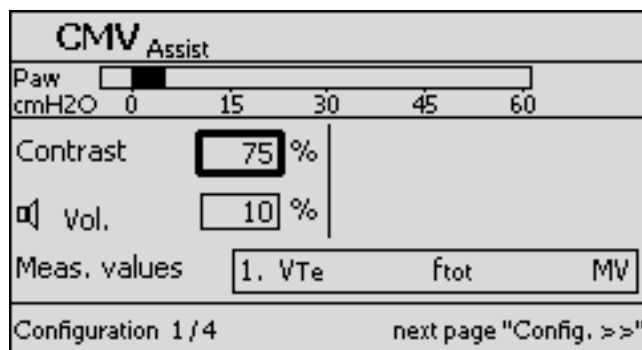
The settings selected in »**Configuration**« mode remain stored even when the ventilator is switched off.

The following information about the status of the ventilator can be displayed in »**Configuration**«:

- Total operating hours
- Operating hours since the last inspection and maintenance
- Software version
- Device identification number

Setting the Screen Contrast

- Press »**Config.** ▢▢« key repeatedly until »**Configuration 1/4**« appears.
- Turn dial knob to select the item »**Contrast**«. Press dial knob to activate.
- Turn control knob to adjust screen contrast. The contrast changes. Press dial knob to confirm. The set contrast is now in effect.



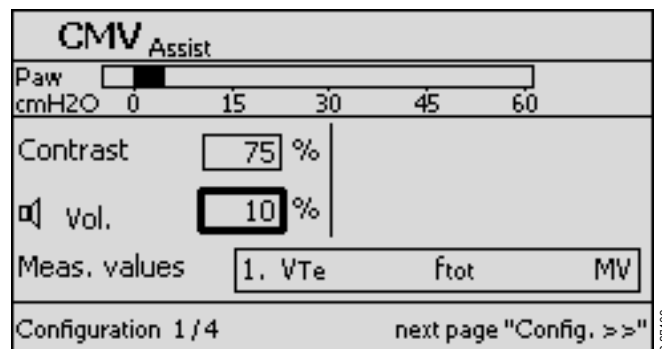
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Adjusting the Volume of the Audible Alarm

Display (example):

- Press »Config. ▷▷« key repeatedly until »Configuration 1/4« appears.
- Turn dial knob to select item »Vol.«.
Press dial knob to activate.
- Turn dial knob to adjust volume.
Press dial knob to confirm.

After the setting has been confirmed, the audible alarm will sound once to enable you to judge the set volume.



WARNING !

Always adjust audible alarm volume to a level that ensures the operator will be alerted when alarms occur. Failure to identify and correct alarm situations may result in patient injury.

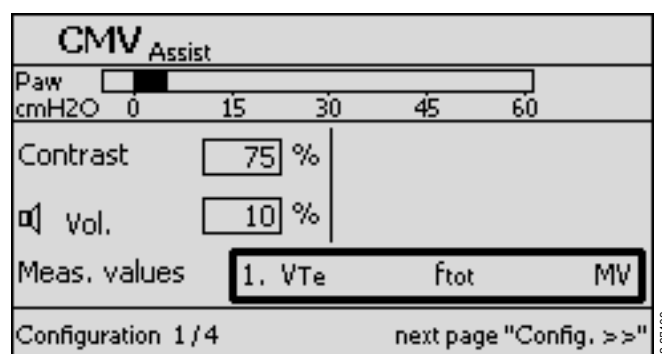
Configuring the Measured Values Field

Select one of 6 possible combinations of measured values:

- Press »Config. ▷▷« key repeatedly until »Configuration 1/4« appears.
- Turn dial knob to select item »Meas. values«.
Press dial knob to activate.
- Turn dial knob to select a combination of measured values.
Press dial knob to confirm.

The following combinations of measured values may be selected

1.	VT _e	ftot	MV
2.	FiO ₂	VT _e	MV
3.	P _{peak}	VT _e	MV
4.	P _{mean}	FiO ₂	MV
5.	P _{mean}	VT _e	MV
6.	P _{peak}	P _{mean}	VT _e



Manual Calibration for O2 Sensor 2

- Required when the following alarm has occurred:
!!! O2 measurement failure
or
- at least monthly.

WARNING !

Always use a reliable independent O2 source during calibration that supplies 100 % O2. In case the calibration procedure is based on a diluted oxygen source, Savina may deliver inaccurate oxygen concentrations without further notification.

NOTE: Manual calibration of O2 sensor 2 may be performed in any ventilation mode.

- Before starting the calibration procedure, replace the central O2 supply with a reliable independent supply that contains 100 % O2 (e.g. O2 cylinder).
 - Press »Config. ▷▷« key repeatedly until »Configuration 2/4« appears.
 - Turn dial knob to select item »O2 cal.«. Press dial knob to release for setting.
 - To start O2 calibration, turn dial knob and select »Start«. Press dial knob to confirm.
- Message in the information line at the bottom of the screen:
Disconnect patient
- Disconnect patient within the next 30 seconds.
 - If necessary, continue ventilating the patient using a separate ventilating device.

Message in the information line at the bottom of the screen:
O2 calibration active

After 60 seconds the following appears in the information line:

- **Reconnect patient**
Immediately reconnect patient.

NOTE: If necessary, the patient may be reconnected at any time. Savina will ventilate as before. Message:

O2 calibration interrupted

In this case, the ventilator continues to operate using the old calibration values.

After calibration, the following message appears:

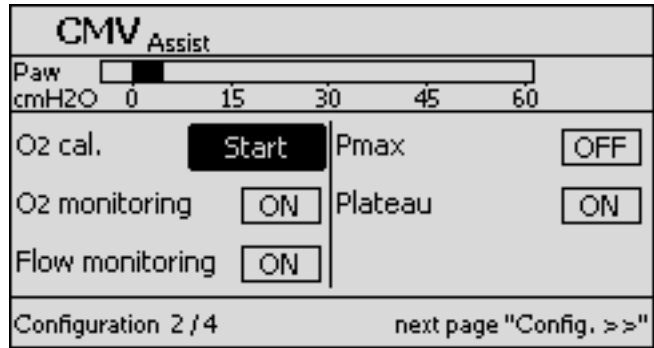
O2 calibration OK

Reconnect Savina to the original O2 source.

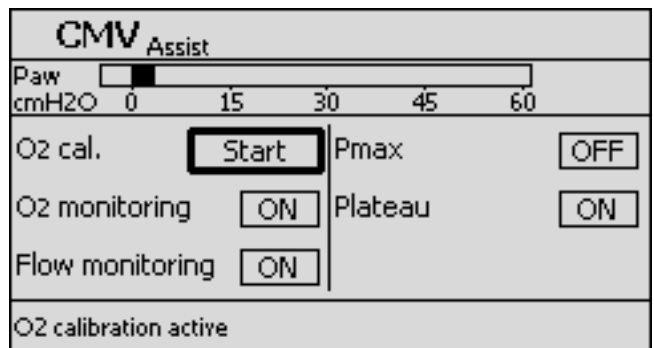
The O2 calibration is completed, Savina ventilates again using the original settings.

NOTE: Disconnection during the calibration procedure would activate a number of alarms. For this reason, Savina turns the respective alarms off during calibration.

If the patient is not reconnected within 30 seconds, Savina continues ventilation with the original settings and all alarms become active again.



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If the following alarm appears after calibration:

!!! O2 measurement failure

- Replace O2 sensor, see page 108.

If the following alarm appears after calibration:

!!! FiO2 low

- Make sure, that the O2 source in use contains 100 % O2 (see WARNING on page 88).

FiO2- or Flow Monitoring ON / OFF

For instance, when a used up O2 or flow sensor cannot be replaced immediately.

WARNING !

In case of a fault in any of the built-in monitoring a substitute has to be provided in order to maintain an adequate level of monitoring. The operator of the ventilator must still assume full responsibility for proper ventilation and patient safety in all situations.

- Press »Config. $\triangleright\triangleright$ « key repeatedly until »Configuration 2/4« appears.
- Turn dial knob to select desired field. Press dial knob to confirm selection.
- Turn dial knob to select »ON«.
- Press dial knob to confirm. The respective monitoring is now activated.
- Turn dial knob to select »OFF«.
- Press dial knob to confirm.

The corresponding monitoring parameter (O2 or Flow) and all associated alarms are now permanently deactivated.

- Provide monitoring alternatives.

Display in the alarm field:

! Flow monitoring off

or

! O2 monitoring off

Display in the information field:

Use external flow monitoring

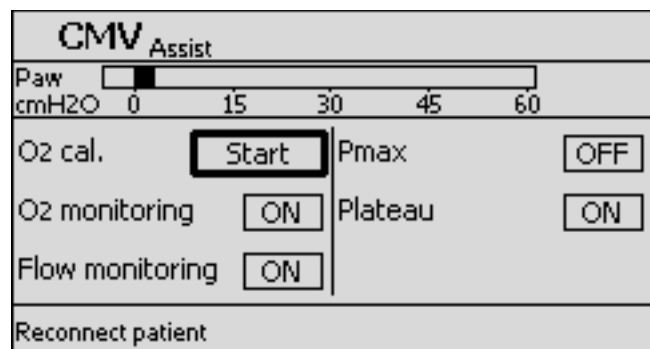
or

Use external O2 monitoring

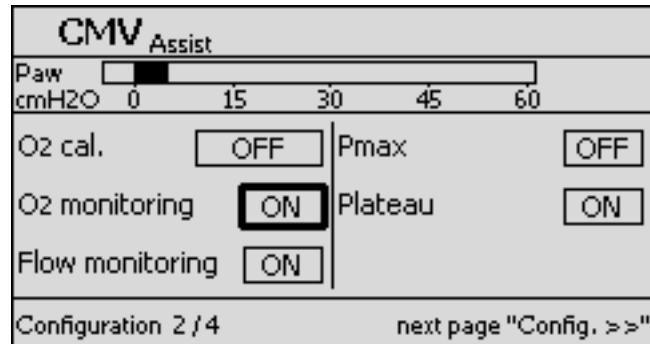
or

Use external flow- and O2 monitoring respectively.

Flow monitoring is automatically activated at each start of the ventilator.



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Configuration

Pmax ON / OFF

When flow monitoring is deactivated, the following measured values are no longer determined:

- MV
- MVspn
- MVleak
- VTpat

NOTE: Even when O2 monitoring is deactivated, the ventilator requires at least Sensor 1 for accurate O2 control, otherwise the blending of O2 and Air would be impaired.

O2 monitoring should only be deactivated when Savina is supplied with air only.

NOTE: O2 monitoring remains deactivated even when the ventilator is switched on again.

In the alarm field, a caution level message will appear:
!! O2 monitoring off

After acknowledging by pressing the »Alarm Reset« key, the advisory message is:
! O2 monitoring off

- Reactivate flow monitoring after replacing the flow sensor.

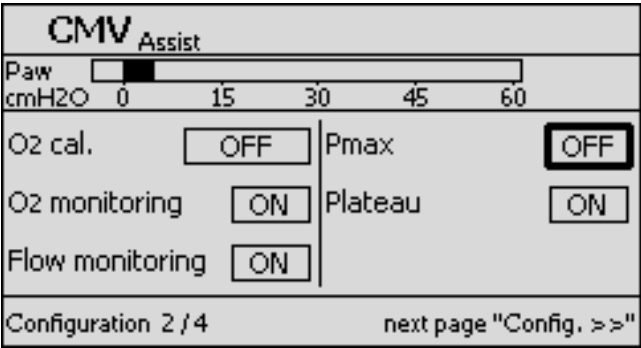
Pmax ON / OFF

To use the pressure limit Pmax in the CMV/CMVAssist, and SIMV, SIMV/PS ventilation modes.

NOTE: In AutoFlow, PCV+, and CPAP modes, this setting is disabled.

The pressure limit value is set with the »Pinsp« key. Savina limits airway pressure to that threshold.

- Press »Config. >>« key repeatedly until »Configuration 2/4« appears.
- Turn dial knob to select item »Pmax«.
Press dial knob to activate.
- Turn dial knob to select »ON«.
Press dial knob to confirm.
Pressure limit »Pmax« is now switched on.
- Turn dial knob to select »OFF«.
Press dial knob to confirm.
Pressure limit »Pmax« is now switched off.



Pressure Plateau ON / OFF

To switch inspiratory pause ON or OFF in the following ventilation modes: CMV/CMVAssist, SIMV, SIMV/PS ventilation modes.

NOTE: In AutoFlow, PCV+, and CPAP modes, this setting is disabled.

When the pressure plateau setting is deactivated, Savina will switch to expiration as soon as the tidal volume is applied.

A setting of inspiratory time T_{insp} will not be applied.

Savina establishes a minimum expiratory time of 500 ms and limits the resulting I:E ratio to a maximum of 4:1.

- Press »Config. ▷▷« key repeatedly until »Configuration 2/4« appears.
- Turn dial knob to select »Plateau« field. Press dial knob to activate.
- Turn dial knob to select »ON«.
- Press dial knob to confirm. Plateau is now switched on.
- Turn dial knob to select »OFF«.
- Press dial knob to confirm. Plateau is now switched off.

NOTE: A pressure plateau can only be activated in ventilation modes CMV/CMVAssist, SIMV, and SIMV/PS. When in modes AutoFlow, PCV+, and CPAP, this setting is without function.

The screenshot shows the 'CMV Assist' configuration screen. At the top, there is a 'Paw' (cmH2O) scale from 0 to 60. Below this, there are four settings: 'O2 cal.' (OFF), 'Pmax' (OFF), 'O2 monitoring' (ON), and 'Flow monitoring' (ON). The 'Plateau' setting is highlighted with a black box and is set to 'ON'. At the bottom, it says 'Configuration 2 / 4' and 'next page "Config. >>"'.

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Selecting the Language

Display (example):

- Press »Config. ▷▷« key repeatedly, until »Configuration 3/4« appears.
- Turn dial knob to select item »Language«.
- Press dial knob to activate.

The following languages can be selected:

- German
- English
- US English
- French
- Italian
- Spanish
- Portuguese
- Chinese
- Japanese
- Russian
- Greek
- Romanian
- Polish

- Turn dial knob to select language.
- Press dial knob to confirm.

NOTE: The newly selected language goes into effect immediately.

The screenshot shows the 'CMV Assist' configuration screen. At the top, there is a 'Paw' (cmH2O) scale from 0 to 60. Below this, there are four settings: 'Language' (US-English), 'Baudrate' (19200), 'dd.mm.yy' (16/05/01), and 'h:m' (10:41). The 'Language' setting is highlighted with a black box. At the bottom, it says 'Configuration 3 / 4' and 'next page "Config. >>"'.

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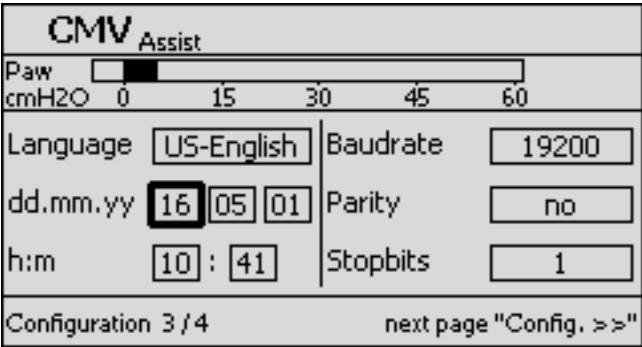
Configuration

Setting Date and Time
Configuring the MEDIBUS Protocol
Displaying Ventilator Data

Setting Date and Time

Required when using the MEDIBUS communications interface

- Press »Config. ▢▢« key repeatedly until »Configuration 3/4« appears.
- Turn dial knob to select »dd.mm.yy« field. Press dial knob to activate.
- Turn dial knob to set the day (dd), Press dial knob to confirm.
- Set month (mm), year (yy), hour (h), and minutes (m) in the same fashion.

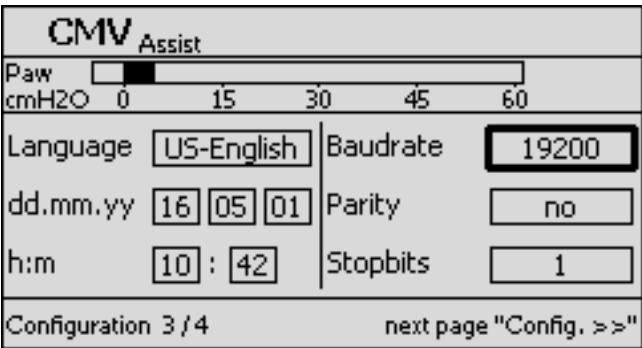


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Configuring the MEDIBUS* Protocol

The following parameters can be set:

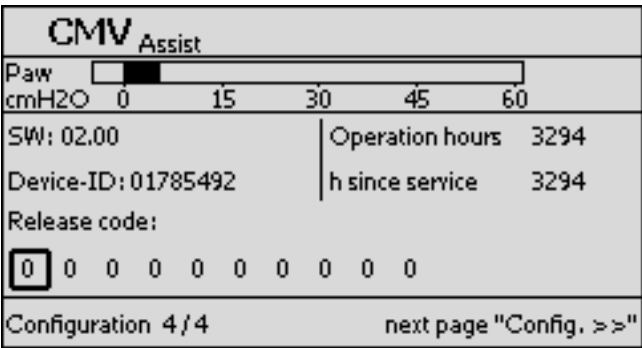
- Baud rate
- Parity check bits
- Number of stop bits
- Press »Config. ▢▢« key repeatedly until »Configuration 3/4« appears.
- Turn dial knob to select field for the corresponding interface parameters, e.g. to select the baudrate. Press dial knob to release parameter for setting.
- Turn dial knob to set value. Press dial knob to confirm.



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Displaying Ventilator Data

- Press »Config. ▢▢« key repeatedly until »Configuration 4/4« appears.
- Savina displays:
- **SW**
Software version of the ventilator
 - **Device-ID**
device-specific identification number of the ventilator
 - **Operation hours**
the total number of hours the device has been operating
 - **h since service**
the number of operating hours since the last preventive maintenance by factory trained and authorized technicians.
 - **Release code:**
Numerical code for releasing available options.



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Return to main page

- Press »Waveforms ▴▴« key until the main page appears, showing a waveform.

* MEDIBUS
Dräger communications protocol for medical devices

Configuring Remote Service (option)

Remote Service allows test and service functions to be performed from a central remote server via a telephone line and modem. Release of this option by DrägerService and special accessories are required in order to use Remote Service.

When Remote Service has been released, the on-line connection mode can be set:

- **Remote Service**
On-line connection mode, with the following values:
 - **Off**
Possibility of a connection between Savina and the remote server is disabled.
 - **Call**
Savina calls the remote server.
 - **Listen**
Savina waits for a call from the remote server.
- **Task**
This parameter is only available if »Call« or »Listen« has been selected under **Remote Service**.
Remote Service use mode, with the following values:
 - **Problem Call**
Remote Service is provided when a malfunction occurs.
 - **Routine Call**
Remote Service is performed for routine ventilator maintenance.

For operation of the Remote Service function, please refer to the separate Instructions for Use.

- Keep pressing the »Config. ▷▷« key until »Configuration 4/4« appears.
- Select parameter box of "Remote Service" by turning the dial knob.
Press dial knob to activate for setting.
- Turn dial knob to set value.
Press dial knob to confirm.

CMV Assist	
Paw	0
cmH ₂ O	0 15 30 45 60
SW: 00.03	Device-ID: 06892527
Operation hours 8533	Remote Service Call
h since service 1598	Task Routine Call
Release code:	0 0 0 0 0 0 0 0 0 0
Configuration 4/4 next page "Config. >>"	

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Care

Dismantling Components 96

Disinfecting / Cleaning / Sterilizing 99

Disinfecting / Cleaning / Sterilizing Schedule for the Savina
Intensive Care Ventilator 101

Re-assembly 101

Care

- Clean and prepare the ventilator after each patient.

WARNING !

To avoid risks to hospital staff and patients, disinfect and clean ventilator after use.

Always use ventilator that has been cleaned and disinfected and has been successfully tested to be ready for operation.

- Always observe accepted hospital hygiene protocols regarding the frequency of patient circuit and expiratory valve changes.

Recommendation:

- Change patient circuit system and expiratory valve as needed. Keep replacement systems ready.

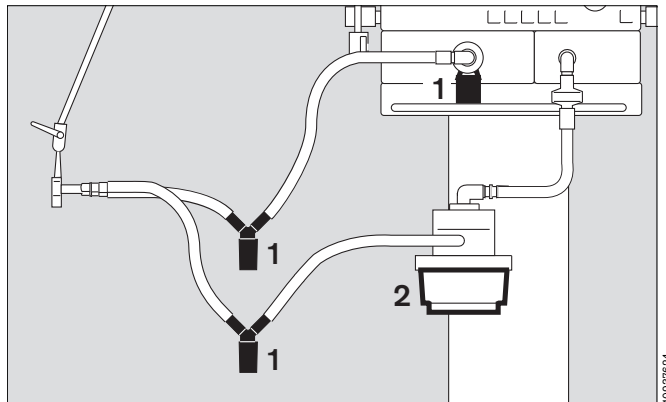
WARNING !

Always follow accepted hospital procedures for handling equipment contaminated with body fluids.

Dismantling Components

- Switch off both ventilator and humidifier, and remove their power plugs from wall outlets.

- 1 Empty water trap on the expiratory valve.
- 2 Empty water container of the humidifier.

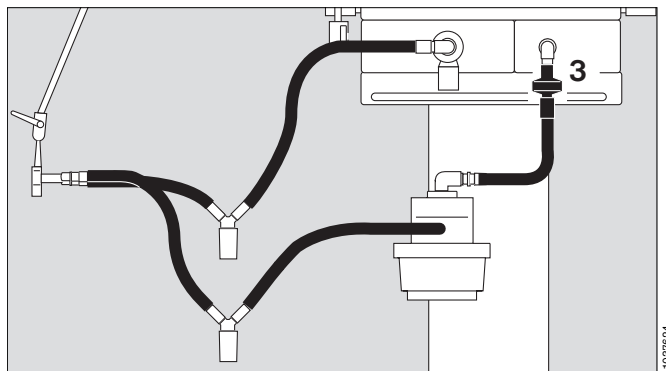


Patient circuit

- Remove patient circuit from ventilator ports.

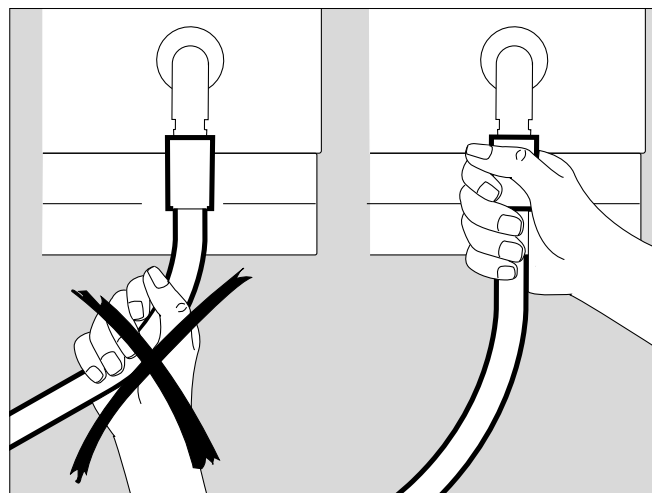
For a Draeger reusable patient circuit:

- Remove water traps from patient circuit. Remove collecting jars from water traps and the expiratory valve.
 - Prepare patient circuit, water traps, and associated collecting jars, as well as the the patient wye, for disinfection and cleaning by autoclaving.
- 3 Remove bacteria filter and process in accordance with its respective instructions for use.

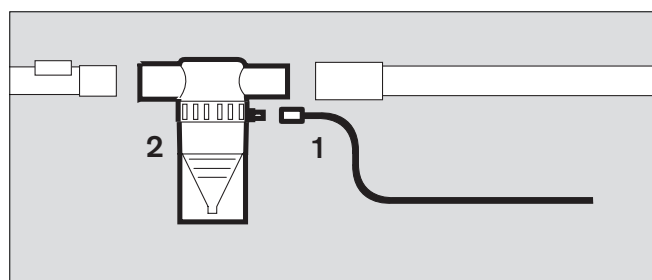


CAUTION !

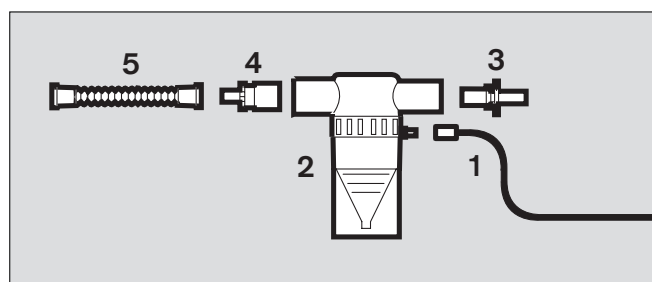
When removing a reusable patient circuit, always grasp hoses by their sleeve, never by the hose itself, to avoid possibly tearing the hose at the sleeve or ripping it out of the sleeve.

**Nebulizer (available option)***

- 1 Remove nebulizer hose from the nebulizer and from the nebulizer port on the ventilator.
- 2 Detach nebulizer from the patient circuit (adult patient circuit), or



- 2 remove nebulizer from the infant patient circuit.
- 3 Pull catheter connector (tapered ISO connector $\varnothing 15 / \varnothing 11$) from the nebulizer input.
- 4 Pull adapter (tapered ISO connector $\varnothing 22 / \varnothing 11$) from the nebulizer output.
- 5 Pull corrugated patient circuit segment from the connector.



- Dismantle and process nebulizer in accordance with its accompanying Instructions for Use.

* Please take into account when using the nebulizer on an infant patient circuit:

An inspiratory flow of 18 L/min is needed to trigger the nebulizer gas supply. Small patients, or any patient who has a low initial inspiratory flow rate will not trigger the nebulizer gas supply during the early part of the breath. Under these conditions, the nebulized drug would not be distributed well to the distal airways. For this reason, nebulizer mode is recommended for use only with adults and larger children under conditions when the nebulizer flow will be triggered during early inhalation.

Flow sensor

- 1 Push flow sensor to the left as far as it will go and
- 2 pull out.

CAUTION !

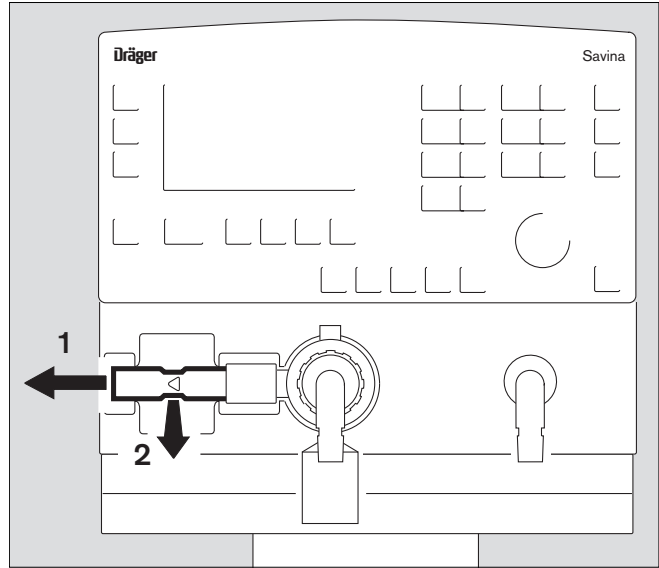
Flow sensor is not compatible with parts washer equipment and may not be autoclaved or steam-sterilized. It is not temperature stable and would be destroyed.

- Disinfect flow sensor for about 1 hour in a 70 % ethanol solution.

WARNING !

Vent flow sensor after disinfection with ethanol for at least 30 minutes or rinse with sterile water. Otherwise, residual ethanol vapors might ignite and destroy the sensor during calibration.

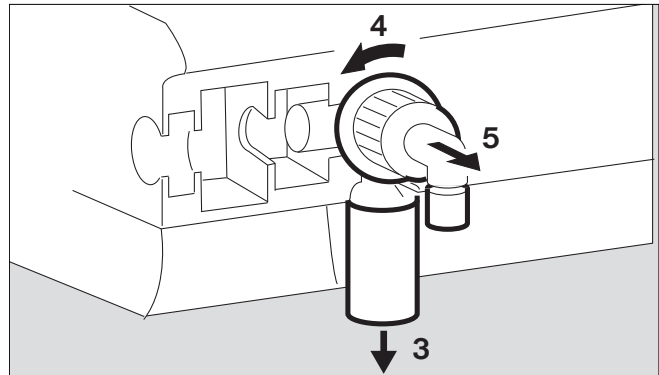
NOTE: The flow sensor may be reused as long as it can be calibrated successfully.



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Expiratory valve

- 3 Remove collecting jar from water trap.
- 4 Turn knurled bushing to the left and
- 5 remove expiratory valve.



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- 6 Remove diaphragm.
- 7 Remove rubber bushing.

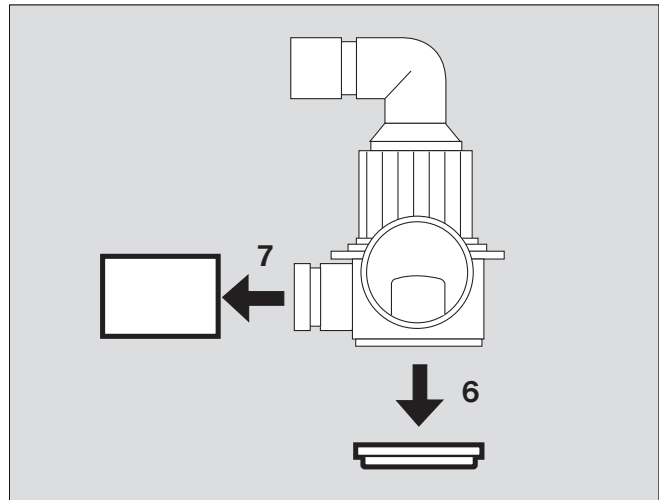
CAUTION !

Do not disassemble expiratory valve beyond removing diaphragm!

NOTE: The expiratory valve together with its diaphragm, rubber bushing, and the removed collecting jar of the water trap may be disinfected and cleaned by autoclaving or sterilizing.

Breathing gas humidifier

- Disassemble and prepare for disinfection/sterilization according to its Operating Instructions.



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Disinfecting / Cleaning / Sterilizing

CAUTION !

Certain components of the ventilator consist of materials that are sensitive to certain organic solvents sometimes used for cleaning and disinfecting (e.g., alkylamines, phenols, halogen releasing compounds, oxygen releasing compounds, strong organic acids, etc.). Exposure to such substances may cause damage that is not always immediately recognized.

To prevent any damage, we recommend that only detergents and disinfectants are used that are compatible with the device, e.g. surface disinfectants on the basis of aldehydes or quarternary ammonium compounds for disinfection. Ensure that all disinfectants are registered with the U.S. Environmental Protection Agency for use as intended. Always follow the instruction labels specifically with respect to prescribed concentrations and the necessary exposure times. Disinfectants often contain – besides their main active agents – additives that can also damage materials. If in doubt, ask the supplier/manufacturer of the disinfectant/cleaning agent.

WARNING !

Sterilization of parts in ethylene oxide (EtO) may lead to a patient health risk:
Patients may become exposed to EtO that may have diffused into components.

WARNING !

To avoid any risk of infection for hospital staff or other patients, clean and disinfect ventilator after use.
Follow all accepted hospital procedures for disinfecting parts contaminated by body fluids (protective clothing, eyewear, etc.).

- Savina ventilator with mobile stand
- hinged circuit support arm
- gas supply hoses
- Wipe disinfect with a disinfectant based on the suggested active ingredients.
 Always comply with manufacturer's instructions.

Care

Disinfecting / Cleaning / Sterilizing

- Reusable patient circuit
- reusable patient wye
- water traps and collecting jars
- expiratory valve body
- expiratory valve diaphragm
- expiratory valve collecting jar
- May be disinfected in a moisture saturated environment at 93 °C (200 °F) for 10 minutes. **Use detergent only.**

- Reusable patient circuit
- reusable patient wye
- water traps and collecting jars
- expiratory valve body
- expiratory valve diaphragm
- expiratory valve collecting jar
- temperature sensor
- may be steam-sterilized at 134 °C (273 °F).

- Nebulizer
- Process in accordance with its accompanying instructions for use.

- Bacteria filter
- Process in accordance with its accompanying instructions for use.

Disinfecting / Cleaning / Sterilizing Schedule for the Savina Intensive Care Ventilator

Applicable for use with non-infectious patients.

For infectious patients, all parts that conduct breathing gas must be additionally sterilized after disinfecting and cleaning.

The breathing gas conducting parts listed here can be steam-sterilized at 134 °C. See "Sterilizing" column.

This table serves as a guideline only.

Always follow accepted hospital procedures and protocols for cleaning and disinfecting

Part	How often	How			
		Disinfecting and cleaning			Sterilizing
		Autoclaving at 93 °C, 10 minutes	Wiping ¹	Bath immersion	Steam 134 °C, 10 minutes
Savina ventilator	after each patient	no	outside	no	no
mobile stand circuit support arm gas supply hoses	after each patient	no	outside	no	no
patient circuit, patient wye, water traps and collecting jars	after each patient/ weekly	yes	no	possible	yes
expiratory valve	after each patient/ weekly	yes	no	possible	yes
flow sensor	after each patient/ weekly	no ²	outside	possible ²	no
temperature sensor (optional)	after each patient/ weekly	no	yes	no	yes

1. with an approved wipe disinfectant based on the recommended active ingredients, see page 99

2. Special treatment, bath disinfect in 70 % ethanol, see page 98

Re-assembly

Please refer to "Assembly of Components" on page 32 in chapter "Preparation".

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Maintenance

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Maintenance

CAUTION ! Maintenance

The device must be inspected and serviced at regular intervals. A record must be kept on this preventive maintenance. We recommend obtaining a service contract with DraegerService through your vendor.
For repairs we recommend that you contact DraegerService.

WARNING !

To avoid any risk of infection, clean and disinfect ventilator and accessories before any maintenance according to established hospital procedures - this applies also when returning ventilators or parts for repair.

WARNING !

Never operate the ventilator if it has suffered physical damage or does not seem to operate properly.
We recommend that you contact DraegerService for maintenance service for the Savina Ventilator.

WARNING !

Treatment of batteries and O₂-sensor capsules:
Do not throw into fire! Risk of explosion.
Do not force open! Danger of bodily injury.
Follow all local, state, and federal regulations with respect to environmental protection when disposing of batteries and O₂-sensor capsules.

WARNING !

Both breathing and cooling air are drawn in through the filter cover.
Do not block air intake, do not place ventilator immediately against a wall – risk of overheating the ventilator.

WARNING !

When servicing the ventilator, always use replacement parts that are qualified to Draeger standards.
Draeger cannot warrant or endorse the safe performance of third party replacement parts for use with the Savina ventilator.

CAUTION !

Never operate the ventilator without a microfilter at the air intake. The inspiratory side of the ventilator and patient circuit would become dirty.

Maintenance Intervals

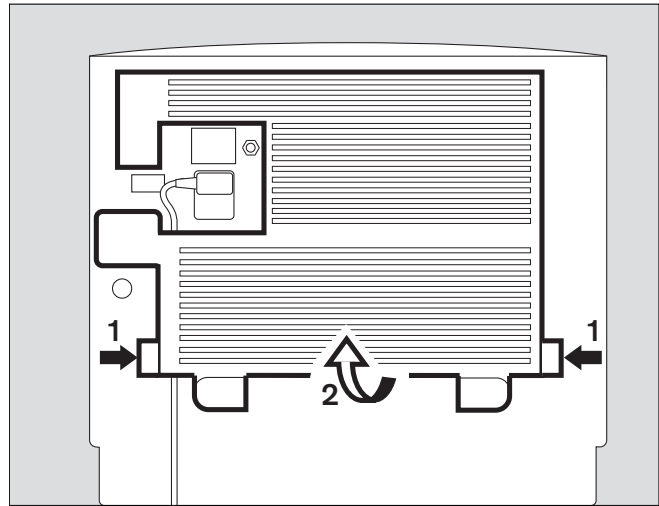
O ₂ sensors	Replace when the following message is displayed: !!! O₂ measurement failure or when calibration is no longer possible. For disposal of spent sensor capsules, see page 109.
Microfilter	Replace every year, see page 106. Disposal with normal domestic waste.
Dust filter set	Replace every year, see page 107. Disposal with normal domestic waste.
Blower unit	To be replaced after 20,000 hours of operation or after 8 years (whichever comes first) by DraegerService or factory trained and authorized technical service personnel.
Lead-gel battery	To be replaced every 2 years by DraegerService or factory trained and authorized technical service personnel. Lead-gel batteries should be disposed of as special waste, see page 109.
Filter in O ₂ inlet	To be replaced every 6 years by DraegerService or factory trained and authorized technical service personnel.
Real-time clock module	To be replaced every 6 years by DraegerService or factory trained and authorized technical service personnel.
Pressure reducer	To be replaced every 6 years by DraegerService.
Equipment inspection and service	For the first time after 2 years or after 6,000 hours of operation – whichever comes first; thereafter annually or after 6,000 hours of operation – whichever comes first For other servicing (e.g. six-monthly inspection, etc.), contact DraegerService. To be performed by DraegerService or factory trained and authorized technical service personnel.

User Replaceable Parts

Replacing the microfilter

- Filter should be replaced every year.

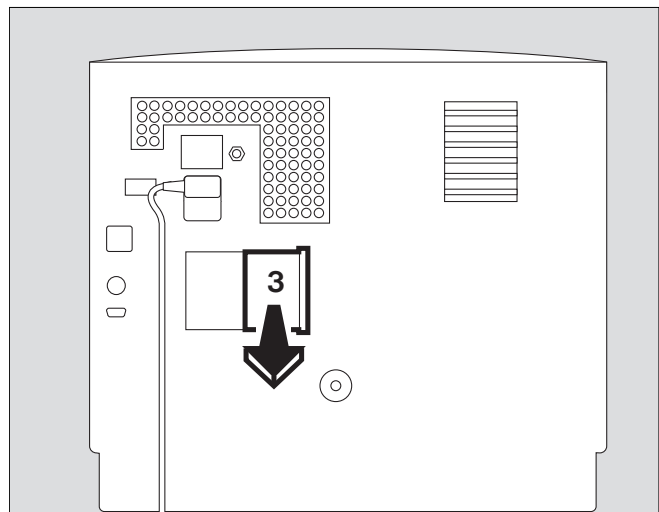
- 1 Hold down both latches,
- 2 Lift filter cover and remove.



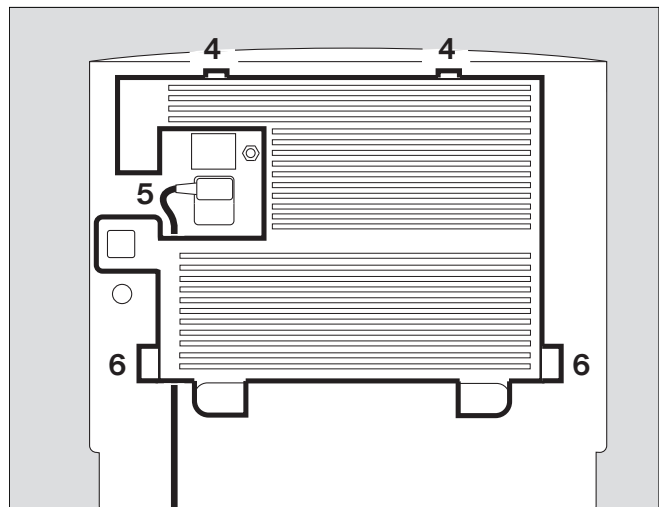
- 3 Remove used microfilter from its housing.
- Slide new microfilter into housing as far as it will go.
 - Dispose of used microfilter together with domestic waste.

CAUTION !

Never operate the ventilator without a microfilter. The inspiratory side of the ventilator and patient circuit would become dirty.



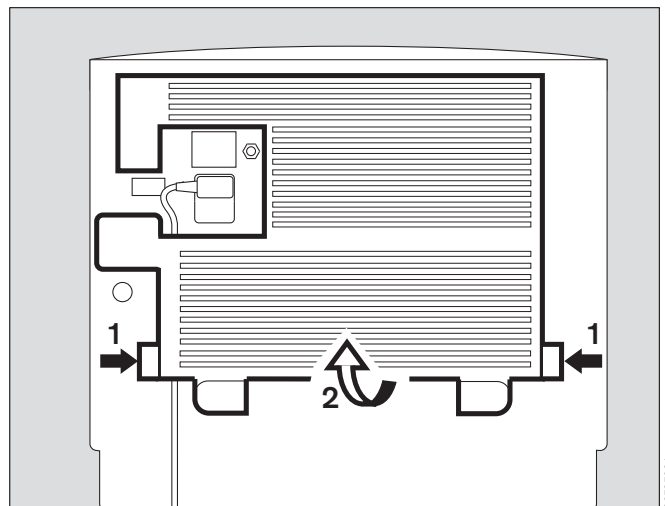
- 4 Insert filter cover with its two lugs into rear panel.
- 5 Position power cable under filter cover.
- 6 Push latches into housing until they engage.



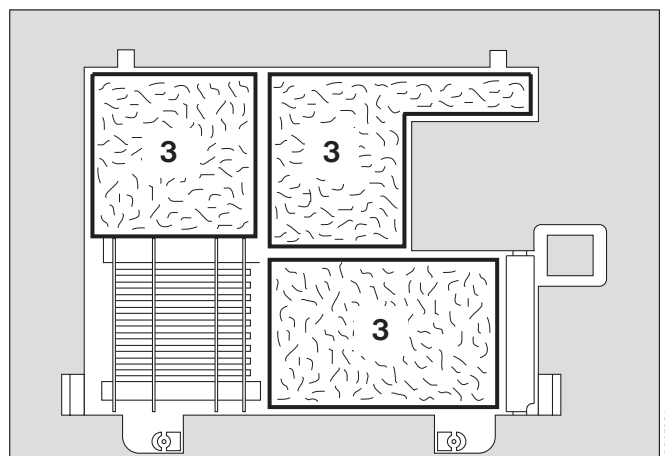
Replacing the dust filter set

- Inspect for soiling every 4 weeks, clean or replace as necessary.

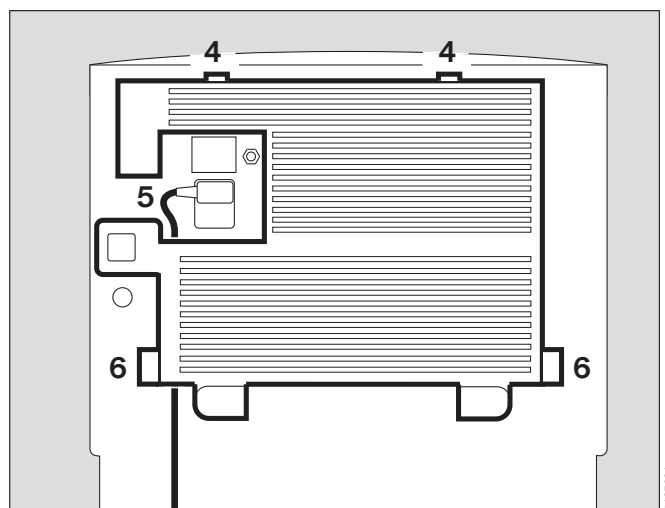
- 1 Hold down both latches.
- 2 Lift filter cover and remove.



- 3 Remove used dust filters from filter cover.
- Install new dust filters.
- Dispose of used dust filters with domestic waste.



- 4 Slide the two lugs of the filter cover into the rear panel.
- 5 Place AC power cable under the filter cover.
- 6 Push latches into their openings until they engage.

**WARNING !**

Both breathing and cooling air are drawn in through the filter cover.

Do not block air intake, do not place ventilator immediately against a wall – risk of overheating the ventilator.

Replacing the O₂ Sensors

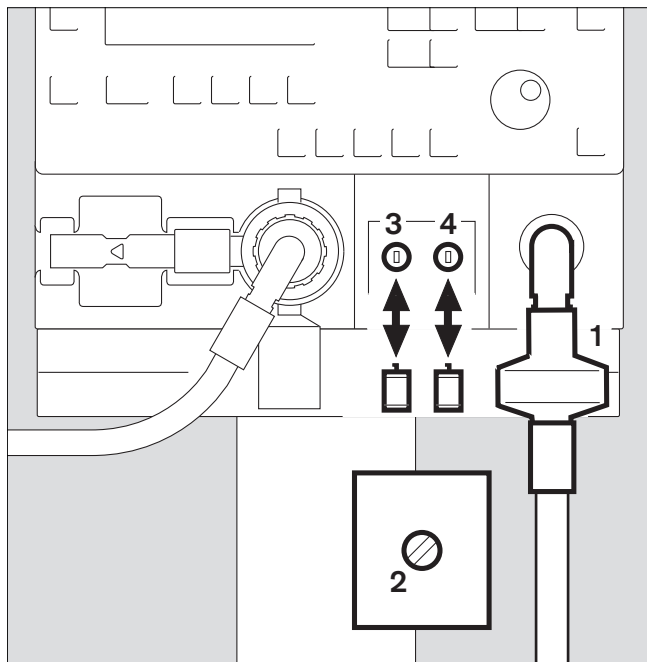
- If the following message appears:
!!! O₂ measurement failure
Replace O₂ sensor 1
or
!!! O₂ measurement failure
Replace O₂ sensor 2
- If calibration is no longer possible.

- 1 Swivel inspiratory port downwards
- 2 Undo screw (use coin) and remove cover plate,
- 3/4 Remove used O₂ sensor from housing
- 3/4 Slide new O₂ sensor into the respective housing for "Sensor 1" or "Sensor 2". Turn using light pressure until O₂ sensor slides further into the housing.
- 2 Screw cover plate back into place.

Sensor 1:
is automatically calibrated after installation.

- Sensor 2:
- Wait for at least 20 minutes of warm-up, then
 - calibrate manually, see page 88.

NOTE: The internal battery supplies current to the two O₂ sensors even when Savina is switched off. This enables Savina to measure valid O₂ values as soon as it is switched on. If the internal battery is discharged, Savina does not supply any O₂ values for the first 20 minutes after switching on. Blending of O₂ is performed at reduced accuracy during this time.



Using an External Battery

Either 12 V or 24 V external batteries may be connected. It is recommended to use 24 V batteries (2 x 12 V batteries connected in series) with a minimum capacity of 15 Ah each. The efficiency of the DC/DC converter and the resulting operating hours are significantly greater for such an arrangement than for 12 V batteries of comparable capacity.

Disposal of Batteries and O₂ Sensors

WARNING !

Treatment of batteries and O₂-sensor capsules:
Do not throw into fire! Risk of explosion.
Do not force open! Danger of bodily injury.
Follow all local, state, and federal regulations with respect to environmental protection when disposing of batteries and O₂-sensor capsules.

Internal Batteries

The permanent batteries installed in the Savina ventilator contain harmful substances (lead and sulphuric acid). They should be removed and disposed of by DraegerService or factory trained and authorized technical service personnel.

O₂ sensors

- Dispose of O₂ sensors in the same way as batteries (contain sulphuric acid).

Information may be obtained from local environmental and public health authorities or from approved waste disposal companies.

Considerations for Extended Storage

If Savina is stored for longer than 14 days without power:

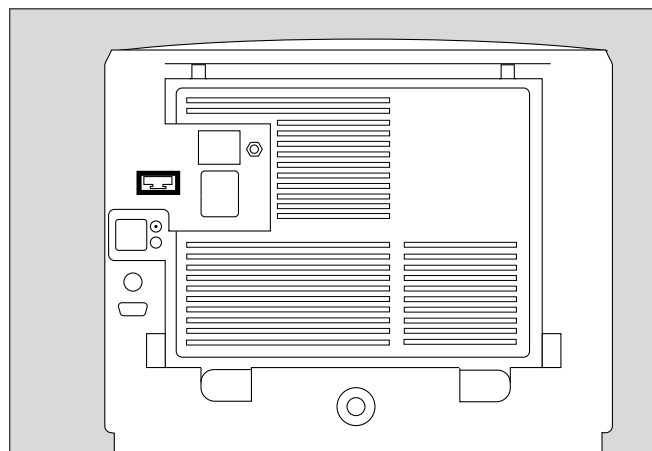
- Remove fuse for internal battery. This will prevent an undesirable deep discharge of the internal battery, which otherwise would continue to supply current to the O₂ sensors.

NOTE: Charge internal battery before removing fuse.

Even with the fuse removed, the battery will slowly discharge. Therefore, the internal batteries should be recharged after 6 months at the latest.

CAUTION !

Avoid storing the ventilator for extended periods at temperatures over 50 °C.
 The internal battery and O₂ sensors may be damaged, or equipment life may be shortened



Correct Disposal of Ventilator

- at the end of its useful life.
- Contact a licensed waste disposal company for appropriate disposal of Savina.
 Follow all local, state, and federal regulations with respect to environmental protection when disposing of the ventilator.

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Troubleshooting

Troubleshooting 112

Troubleshooting

Alarm messages in the alarm display field are displayed in hierarchical order.
For example, if two faults are detected simultaneously, the more urgent of the two is displayed.

The priority level of the alarm messages (see page 68 for definitions) is identified by exclamation marks:

- Warning = !!! Message with top priority
- Caution = !! Message with medium priority
- Advisory = ! Message with low priority

Savina displays a help text in the information field when certain alarm messages occur.
In the table below, messages are listed in alphabetical order.
This table is intended to help identifying possible causes of an alarm
and to assist with prompt corrective action.

Message	Cause	Remedy
!!! Airway pressure high	The upper alarm limit for the airway pressure has been exceeded. Patient is "fighting" the ventilator, coughing.	Check patient condition. Check ventilation pattern. Correct alarm limit if necessary.
	Kinked patient circuit.	Check patient circuit and tube.
!!! Airway pressure low	Leaking cuff.	Inflate cuff and perform leak test.
	Leak or disconnection.	Check patient circuit for tight connections. Check that the expiratory valve is properly engaged.
!!! Amb. press. meas. failure	Internal sensor for absolute pressure faulty.	Due to a fault in the ambient pressure measurement, Savina calculates, in the absence of current measurements, tidal volume VT and minute ventilation MV on the basis of 1013 mbar ambient pressure. You may continue to use Savina if the "Airway pressure high" alarm is set correctly and uncompensated values for VT and MV can be tolerated. Check patient condition closely. Call DraegerService.

Message	Cause	Remedy
!!! Apnea	Patient's spontaneous breathing has stopped.	Apply controlled ventilation.
	Flow sensor not calibrated or faulty.	Calibrate flow sensor. Replace if necessary.
	Apnea alarm delay time »TApnea $\sqrt{\Delta}$ « is set to a value less than the time for one breath cycle (»TApnea $\sqrt{\Delta}$ « < 60/f).	Extend apnea alarm delay time »TApnea $\sqrt{\Delta}$ «.
	Disconnection.	Reconnect.
! Apnea Alarm off	Apnea monitoring has been switched off.	Reset apnea alarm delay time »TApnea $\sqrt{\Delta}$ « to the desired value as necessary.
!! Apnea ventilation	Since an apnea was detected, the system has been automatically switched over to mandatory ventilation.	Check ventilation mode. To return to the original ventilation mode: Press »Alarm Reset« key.
! Atmospheric pressure high	The device is being used at too high atmospheric pressure.	Use Savina within the specified atmospheric pressure range, see "Technical Data" on page 132.
	One of the pressure sensors is faulty.	Due to a fault in the ambient pressure measurement, Savina calculates, in the absence of current measurements, tidal volume VT and minute ventilation MV on the basis of 1013 mbar ambient pressure. You may continue to use Savina if the "Airway pressure high" alarm is set correctly and uncompensated values for VT and MV can be tolerated. Check patient condition closely. Call DraegerService.
! Atmospheric pressure low	The device is being used at too low atmospheric pressure.	Use Savina within the specified atmospheric pressure range, see "Technical Data" on page 132.
	One of the pressure sensors is faulty.	Due to a fault in the ambient pressure measurement, Savina calculates, in the absence of current measurements, tidal volume VT and minute ventilation MV on the basis of 1013 mbar ambient pressure. You may continue to use Savina if the "Airway pressure high" alarm is set correctly and uncompensated values for VT and MV can be tolerated. Check patient condition closely. Call DraegerService.

Message	Cause	Remedy
!!! Battery not charging	Battery not charging due to excessive temperature.	Operate Savina at a lower temperature. If a reliable AC supply is available, ventilation with Savina may be continued. This alarm can be acknowledged by pressing »Alarm Reset«. It will then appear as an advisory message (!).
	Battery not charging due to excessive voltage at external sources (AC line power or external DC supply).	Use external sources with correct voltage. If a reliable AC supply is available, ventilation with Savina may be continued. This alarm can be acknowledged by pressing »Alarm Reset«. It will then appear as an advisory message (!). Call DraegerService.
! Battery not charging	Battery not charging due to excessive temperature.	Operate Savina at a lower temperature. If a reliable AC supply is available, ventilation with Savina may be continued.
	Battery not charging due to excessive voltage at external sources (mains or external DC supply).	Use external power sources with correct voltage. If a reliable AC supply is available, ventilation with Savina may be continued. Call DraegerService.
!!! Breathing gas temp. high	Breathing gas temperature above 40 °C.	Turn humidifier off. Use longer inspiratory patient circuit.
!! Check settings	Due to an internal data loss, Savina operates with factory default settings.	This alarm can be acknowledged by pressing the »Alarm Reset« key. Check settings and adjust as necessary.
!!! Device failure XX.YYYY	Ventilator fault.	If the alarm message disappears when pressing the »Alarm Reset« key, ventilation with Savina may be continued. If the alarm message does not disappear when pressing the »Alarm Reset« key, disconnect patient and continue ventilation without delay, using an independent ventilation device. Use PEEP and / or increased inspiratory O ₂ concentration as necessary. Call DraegerService.
		If Savina cannot be switched off: Turn power switch to » O «. Press »Stand by« key for about 3 seconds and press »Alarm Reset« to confirm. This will switch Savina off. Call DraegerService.
!! Device temp. too high	Temperature inside the ventilator has become too high.	Check condition of the dust filter and replace if necessary, page 107.

Message	Cause	Remedy
!!! Exp. valve failure	Expiratory valve not properly engaged.	Install expiratory valve correctly.
	Faulty flow sensor.	Replace flow sensor.
	Faulty expiratory valve.	Replace expiratory valve.
!!! Ext. DC ?	External battery faulty or not sufficiently charged	Disconnect Savina from the external battery and connect to another charged battery.
! Ext. DC supply active	Due to a lack of an AC line power supply, Savina is operating with an external battery or DC on-board supply	Reconnect to AC power supply if necessary. Take note of the capacity of DC power source.
!!! Fan failure	Fan failure.	Savina uses the fan to cool the interior of the ventilator and to avoid an increased risk of fire in the event of an O ₂ leak. If the "!!! Fan failure" alarm message occurs, disconnect patient and continue ventilation without delay, using an independent ventilation device. Use PEEP and / or increased inspiratory O ₂ concentration as necessary. Call DraegerService.
!!! FiO₂ high	Due to a low minute volume MV, the blender has not yet reached steady state.	Message disappears after a short time.
	Faulty blender.	In order to continue ventilation with Savina: Use external O ₂ -monitoring and switch off the built-in O ₂ -monitoring, page 89. Call DraegerService.
!!! FiO₂ low	Due to a low minute volume MV, the blender has not yet reached steady state.	Message disappears after a short time.
	Faulty blender.	In order to continue ventilation with Savina: Use external O ₂ -monitoring and switch off the built-in O ₂ -monitoring, page 89. Call DraegerService.
!!! Flow measurement failure	Water in flow sensor.	Dry flow sensor.
	Faulty flow sensor.	Replace flow sensor.
	Faulty flow measurement.	In order to continue ventilation with Savina: Use external flow monitoring and switch off the built-in flow monitoring, see page 89. Delivered flow and volume may become inaccurate. Call DraegerService.

Message	Cause	Remedy
! Flow monitoring off	Flow monitoring is switched off.	Switch flow monitoring back on, see page 89, or provide adequate external monitoring immediately.
!!! Flow sensor?	Flow sensor not fully inserted in rubber grommet of expiratory valve.	Insert flow sensor correctly.
!!! High frequency	Patient is breathing at a high spontaneous frequency (tachypnea). Monitored (overall) breath rate is too high.	Check patient condition. Check ventilation pattern. Correct alarm limit if necessary.
!!! Insp/Exp cycle failure	Ventilator does not deliver breathing gas.	Set a CMV rate of at least 4/min.
	Apnea alarm delay time »TApnea $\sqrt{\Delta}$ « is set to a value less than the time for one breath cycle (»TApnea $\sqrt{\Delta}$ « < 60/f).	Extend apnea alarm delay time »TApnea $\sqrt{\Delta}$ «.
	Disconnection	Reconnect
! Insp. hold interrupted	The »Insp. hold« key was held down longer than 15 seconds.	Release »Insp. hold« key.
!!! Int. batt. almost discharged	Time for operation from internal battery has almost expired. Remaining available battery capacity is less than 10 %. Savina is about to stop working.	Immediately connect to AC line power, external battery, or an on-board DC system.
! Int. batt. almost discharged	AC line power or external DC connected; internal battery almost discharged.	Do not switch Savina over to operate from its internal battery. Charge battery
!! Int. battery activated	Savina is being supplied via the internal battery because no AC, external battery, or on-board DC supply is available. See "Operation From the Internal Battery" on page 50.	Restore AC line power or supply from a charged external battery or an on-board DC system. This alarm can be acknowledged by pressing »Alarm Reset«. It will then appear as an advisory message (!).
! Int. battery activated	Savina is being supplied via the internal battery because no AC, external battery, or on-board DC supply is available. See "Operation From the Internal Battery" on page 50.	Restore AC line power or supply from a charged external battery or an on-board DC system.
!!! Int. battery failed	Internal battery has failed.	If a reliable line power supply is available, ventilation with Savina may be continued. This alarm can be acknowledged by pressing the »Alarm Reset« key; it will then appear as an advisory message (!). Call DraegerService.

Message	Cause	Remedy
! Int. battery failed	Internal battery has failed.	If a reliable line power supply is available, ventilation with Savina may be continued. Call DraegerService.
!! Int. battery low	Time for operation from internal battery will soon have expired. Remaining available battery capacity is less than 30 %. The message is repeated if the remaining capacity falls below 20 %.	Restore AC line power or supply from a charged external battery or an on-board DC system immediately. This alarm can be acknowledged by pressing the »Alarm Reset« key; it will then appear as an advisory message (!).
! Int. battery low	When running on internal battery: The remaining available battery capacity is less than 30 %.	Immediately restore AC line power or supply from a charged external battery or an on-board DC system
	If AC line power or an external DC supply is available: Internal battery is not yet sufficiently charged.	Continue charging battery.
!! Key xx failed	xx key (e.g. »Alarm Silence«) can no longer be pressed.	Disconnect patient and continue ventilation without delay, using an independent ventilation device. Use PEEP and / or increased inspiratory O ₂ concentration as necessary. Call DraegerService.
!! Key xx overused	Keys pressed very frequently within a short time (e.g. »Alarm Silence« key).	Acknowledge message by pressing the »Alarm Reset« key. If this message appears again: Disconnect patient from Savina and continue ventilation without delay, using an independent ventilation device. Use PEEP and / or increased inspiratory O ₂ concentration as necessary. Call DraegerService.
! Leakage (Not displayed in »Mask/NIV« mode)	Leaking cuff Leak in patient circuit. The calculated leak minute volume MV_{leak} is greater than the measured expiratory minute volume.	Inflate cuff and perform leak test. Check that circuit connections are tight. Verify that collecting jar of the water trap is installed on the expiratory valve.

Message	Cause	Remedy
!!! Mains switch inop.	Savina has not clearly detected the switch position.	Acknowledge message by pressing »Alarm Reset« key. If Savina has to be switched off: First turn power switch to »  «, then switch off Savina. If message appears again: Ventilation with Savina may be continued. If Savina cannot be switched off after ventilation: Turn power switch to »  «. Press »Stand by« key for 3 seconds and press »Alarm Reset« to confirm. This will switch Savina off. Call DraegerService.
!! Main switch overused	Savina has detected very frequent operation of the switch within a short time.	Acknowledge message by pressing »Alarm Reset« key. If message appears again: Ventilation with Savina may be continued. If Savina cannot be switched off after ventilation: Turn power switch to »  «. Press »Stand by« key for 3 seconds and press »Alarm Reset« to confirm. This will switch Savina off. Call DraegerService.
! MEDIBUS COM. failure.	The connector of the MEDIBUS cable has been unplugged during operation.	Reconnect connector and secure against disconnection with the two screws.
	Faulty MEDIBUS cable.	Use a new MEDIBUS cable.
	Faulty interface card.	Ventilation with Savina may be continued. Call DraegerService.
!! Microfilter blocked	Microfilter clogged.	Change microfilter, see page 106.
!!! Microfilter missing	Microfilter missing or not correctly installed.	Install microfilter, see page 106.
!!! MV high	Minute volume has exceeded the upper alarm limit.	Check patient condition. Check ventilation pattern. Correct alarm limit if necessary.
	Flow sensor faulty.	Replace flow sensor.
	Water in flow sensor.	Drain water trap, dry flow sensor.
!!! MV high (cont'd.)	Ventilator fault.	Disconnect patient from Savina and continue ventilation without delay, using an independent ventilation device. Use PEEP and / or increased inspiratory O ₂ concentration as necessary. Call DraegerService.

Message	Cause	Remedy
!!! MV low	Minute volume has fallen below the lower alarm limit.	Check patient condition. Check ventilation pattern. Correct alarm limit if necessary.
	Leak in circuit system.	Ensure that the circuit system is leakproof.
	Faulty flow sensor.	Replace flow sensor.
	Ventilator fault.	Disconnect patient from Savina and continue ventilation without delay, using an independent ventilation device. Use PEEP and / or increased inspiratory O ₂ concentration as necessary. Call DraegerService.
! Nebulizer on	Nebulizer for pharmaceutical aerosols is switched on.	
!!! No int. battery	Internal battery discharged.	Do not switch Savina over to operate from its internal battery. Charge battery
	Internal battery missing, faulty, or not connected, or fuse has failed.	This alarm can be acknowledged by pressing the »Alarm Reset« key; it will then appear as an advisory message (!). If a reliable AC line power supply is available, ventilation with Savina may be continued. Call DraegerService.
! No int. battery	Internal battery discharged.	Do not switch Savina over to operate from its internal battery. Charge battery
	Internal battery missing, faulty, or not connected, or fuse has failed.	If a reliable line power supply is available, ventilation with Savina may be continued. Call DraegerService.
! No nebulization	The patient's inspiratory flow is too low and therefore the flow required for the nebulizer cannot be applied.	If necessary, increase ventilation parameters Flow Acceleration »FlowAcc« or pressure limit »Pinsp« resulting in a higher inspiratory flow.
!!! O₂ measurement failure	O ₂ sensor provides invalid measured values.	Calibrate O ₂ sensor, see page 81. Replace if necessary.
	O ₂ sensor depleted or not installed.	Install new O ₂ sensor, see page 108. Calibrate, see page 81.
	Faulty O ₂ measurement.	Use external O ₂ -monitoring. Switch off internal O ₂ -monitoring (see "FiO ₂ - or Flow Monitoring ON / OFF" on page 89) in order to suppress alarms. Ventilation with Savina may be continued. Call DraegerService.

Message	Cause	Remedy
!! O₂ monitoring off	Upon switching on, Savina notifies that O ₂ monitoring is switched off.	Reactivate O ₂ monitoring, see page 89 or immediately provide adequate external monitoring. This alarm can be acknowledged with the »Alarm Reset« key. It will then appear as an advisory message (!).
! O₂ monitoring off	O ₂ monitoring switched off. Switched-off state has been confirmed.	Switch O ₂ monitoring back on, see page 89 or immediately provide adequate external monitoring.
!!! O₂ supply down	O ₂ supply pressure too low.	Ensure pressure is greater than 39 psi (2.7 bar).
! O₂ supply down	O ₂ supply pressure too low. O ₂ supply pressure is not required when FiO ₂ is set to 21 %.	Ensure pressure is greater than 39 psi (2.7 bar).
!! O₂ supply pressure high	O ₂ supply pressure too high.	Make sure pressure is less than 87 psi (6 bar).
! O₂ supply pressure high	O ₂ supply pressure too high. O ₂ supply pressure is not required when FiO ₂ = 21 % of vol.	Make sure pressure is less than 87 psi (6 bar).
!!! PEEP high	Expiratory limb of patient circuit incorrectly positioned.	Check circuit system and expiratory valve.
	Increased expiratory resistance.	Check bacteria filter. Replace if necessary.
!!! PEEP failure	Set PEEP is not reached.	Check system for leaks. Ventilation with Savina may be continued although the set PEEP may not be reached. Observe patient closely. Call DraegerService.
!!! Pressure meas. failure	Fluid in expiratory valve.	Replace expiratory valve, then disinfect/ clean and dry, see page 99.
	Pressure measurement fault.	Disconnect patient from Savina and continue ventilation without delay, using an independent ventilation device. Use PEEP and / or increased inspiratory O ₂ concentration as necessary. Call DraegerService.
!!! PS > 4 s (not displayed in »Mask/NIV« mode)	The pressure support cycle has been switched off 3 times because of the time limit criterium.	Check circuit system for leaks.
! PS > 4 s (not displayed in »Mask/NIV« mode)	The pressure support cycle has been switched off because of the time limit criterium.	Check circuit system for leaks.

Message	Cause	Remedy
!! Rotary knob failed	Dial knob cannot be turned or pressed.	Disconnect patient from Savina and continue ventilation without delay, using an independent ventilation device. Use PEEP and / or increased inspiratory O ₂ concentration as necessary. Call DraegerService.
!! Rotary knob overused	Knob has been pressed frequently within a brief period of time.	Press »Alarm Reset« key to acknowledge message. If this message appears again: Disconnect patient from Savina and continue ventilation without delay, using an independent ventilation device. Use PEEP and / or increased inspiratory O ₂ concentration as necessary. Call DraegerService.
!!! Service mode active	Savina has been switched to Remote Service mode.	Press »Alarm Reset« to confirm Remote service mode. To continue ventilation with Savina: Disconnect cable from serial interface. Then switch Savina off and on again.
!!! Standby activated	Savina has been switched to standby.	Confirm standby mode by pressing »Alarm Reset«.
!!! Temperature high	Breathing gas temperature in Savina is above 40 °C.	Ensure lower ambient temperature. for patient protection, turn heated humidifier off.
! Temperature high	While still reaching peak pressure, the ventilator is not reaching peak flow values due to high ambient temperature (35 to 40 °C).	Lower ambient temperature.
!!! Temperature meas. failure	Faulty temperature sensor.	Install new temperature sensor.
!!! Temperature sensor ?	Temperature sensor probe has been disconnected during operation.	Reconnect probe.
	Broken sensor cable.	Install new temperature sensor.
!!! Tidal volume high	The upper alarm limit of the applied inspiratory tidal volume VT has been exceeded during three consecutive ventilator breaths.	Check patient condition. Check ventilation pattern. Correct alarm limits, if necessary.
	Leak or disconnection.	Check that all connections of the patient circuit system are leakproof.
! Tidal volume high	The upper alarm limit of the applied inspiratory tidal volume VT has been exceeded.	Check patient condition. Check ventilation pattern. Correct alarm limits, if necessary.
	Leak or disconnection.	Check that all connections of the patient circuit system are leakproof.

Message	Cause	Remedy
!! Tidal volume low	Because of pressure or time limitations, the set tidal volume VT has not been applied in four consecutive ventilator breaths.	Extend inspiration time »T _{insp} « Raise »FlowAcc«. Raise pressure limitation with the »P _{insp} « key. This alarm can be acknowledged with the »Alarm Reset« key. It will then appear as an advisory message (!).
	While using AutoFlow: Because of pressure or time limitations, the set tidal volume VT has not been applied in four consecutive ventilator breaths.	Extend inspiration time »T _{insp} «, raise »FlowAcc«. Raise upper limit for airway pressure »Paw $\sqrt{\text{ }}$ «. This alarm can be acknowledged with the »Alarm Reset« key. It will then appear as an advisory message (!).
! Tidal volume low	Because of pressure or time limitations, the set tidal volume VT has not been applied in two consecutive ventilator breaths.	Extend inspiration time »T _{insp} «, raise »FlowAcc«. Raise pressure limitation with the »P _{insp} « key.
	While using AutoFlow: Because of pressure or time limitations, the set tidal volume VT has not been applied in two consecutive ventilator breaths.	Extend inspiration time »T _{insp} « Raise »FlowAcc«. Raise upper alarm limit for airway pressure »Paw $\sqrt{\text{ }}$ «.
! VT_i high Alarm off	The upper alarm limit for inspiratory tidal volume, »VT _i $\sqrt{\text{ }}$ « has been switched off.	Reset alarm limit »VT _i $\sqrt{\text{ }}$ « to desired monitoring value, as necessary.

What's What

Control Unit 124

Front Connection Block 125

Rear Panel 126

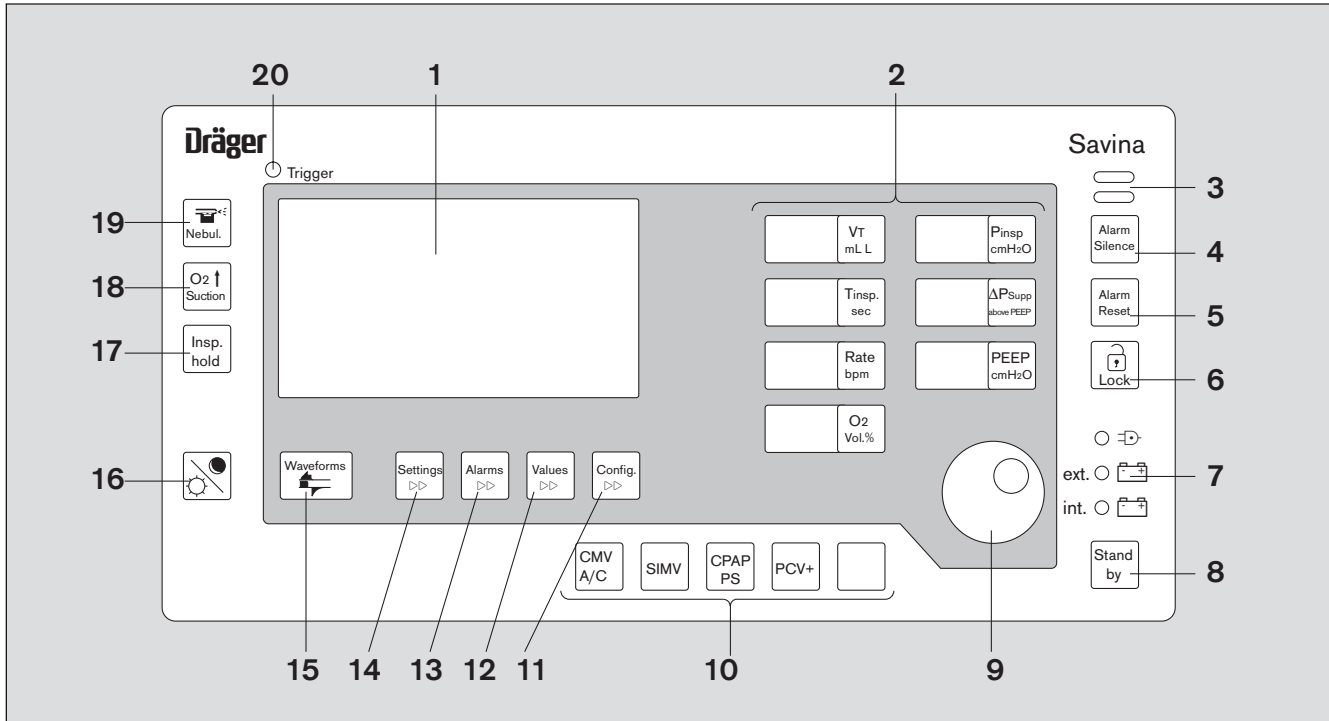
Labels 127

Abbreviations 128

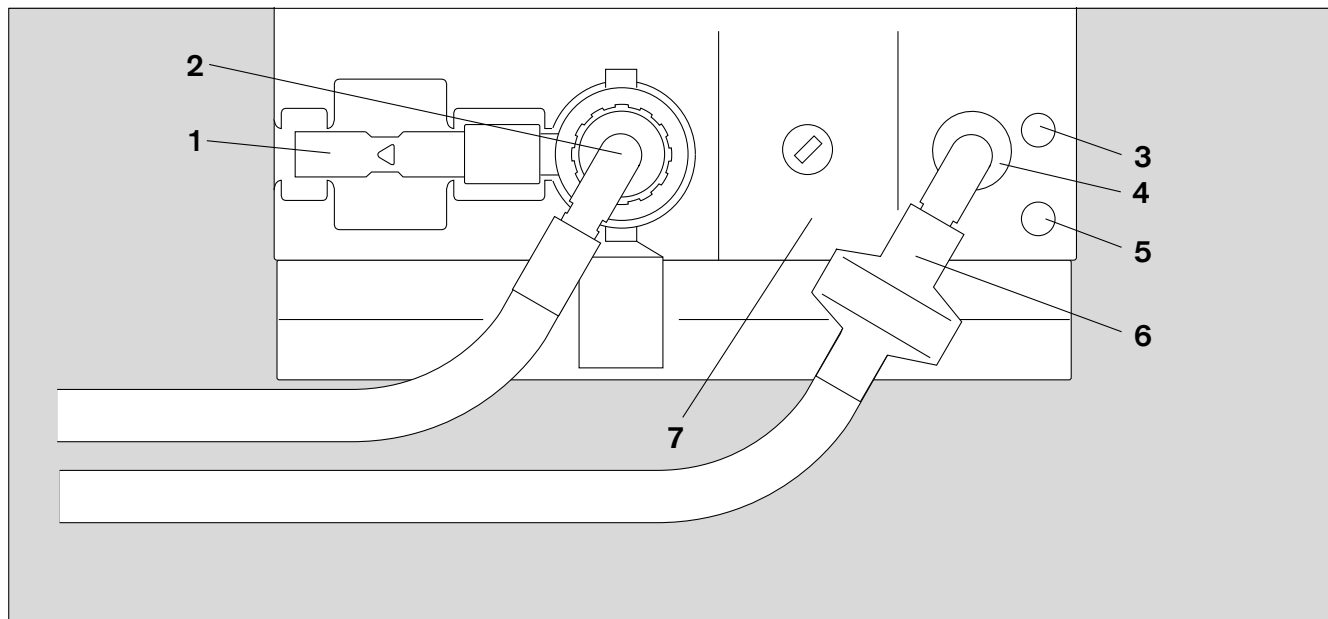
Symbols 130

What's What

Control Unit

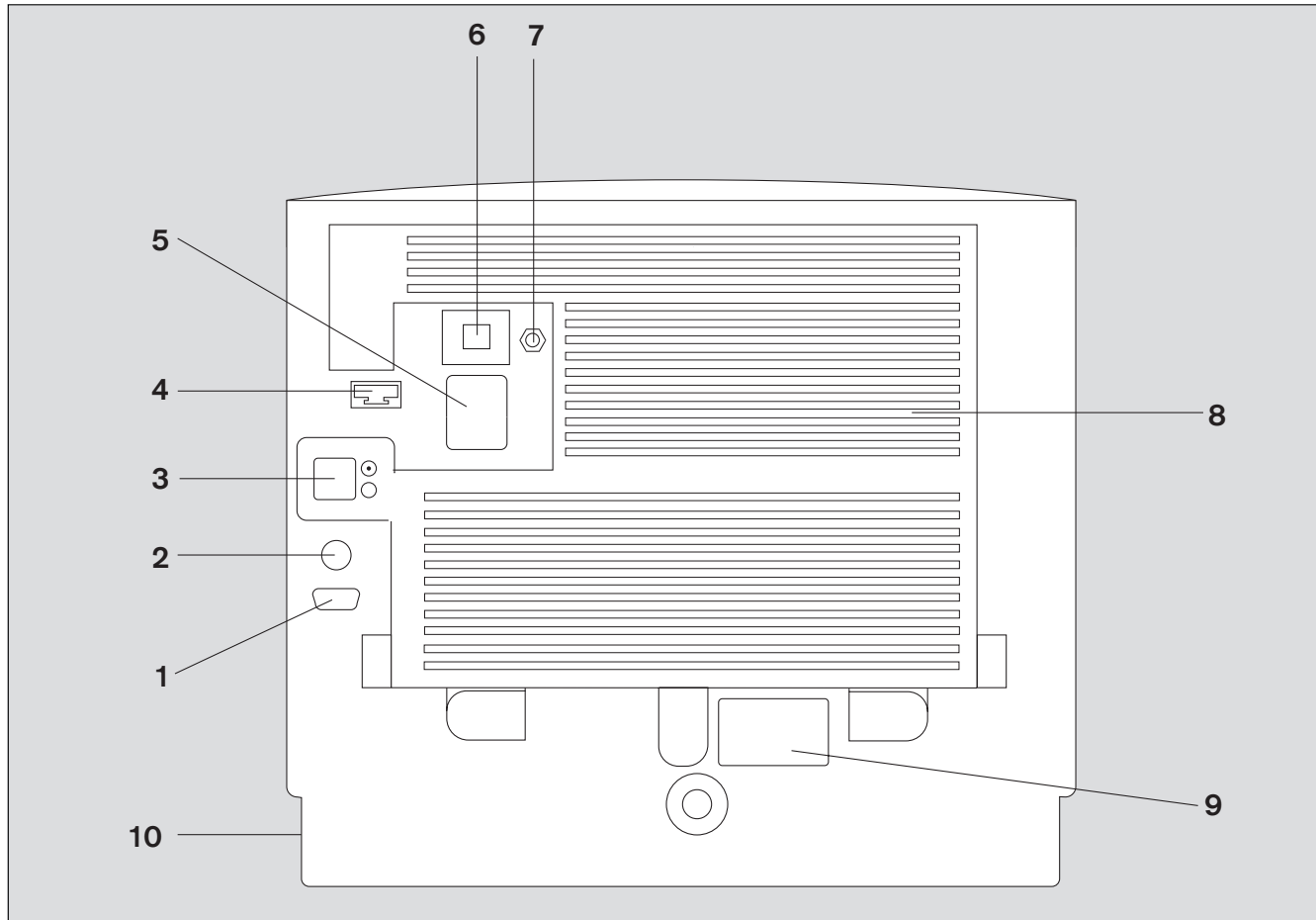


- 1 Screen for displaying application-specific screen pages.
- 2 Parameter keys for setting ventilation parameters and displaying their settings.
- 3 Red and yellow lamps for alarms and advisory messages.
- 4 »Alarm Silence« key for suppressing audible alarms for 2 minutes.
- 5 »Alarm Reset« key for acknowledging alarm messages.
- 6 » Lock« key for protecting against unauthorized modification.
- 7 Power supply indicators:
 - AC line power
 - ext. External battery or DC on-board network
 - int. Internal battery
- 8 »Stand by« key for changing between ventilation and standby mode.
- 9 Central "turn and press" rotary dial knob for selecting and confirming settings.
- 10 Keys for ventilation modes **CMV A/C**, **SIMV**, **CPAP/PS**, **PCV+**.
- 11 »Config. « key for system settings.
- 12 »Values « key for displaying measured values.
- 13 »Alarms « key for setting and displaying alarm limits.
- 14 »Settings « key for setting other ventilation parameters on screen.
- 15 »Waveforms « key for changing to the main screen page and for switching between waveforms (Flow or Paw).
- 16 » / « key for switching the screen brightness between bright / dark.
- 17 »Insp. hold« key for manual inspiration.
- 18 »O₂ ↑ Suction« key for pre-/post-oxygenation during bronchial suction
- 19 » Nebul.« key for switching the pneumatic nebulizer for pharmaceutical aerosols ON / OFF.
- 20 Trigger indicator.

Front Connection Block

- 1 Flow sensor
- 2 Expiratory valve with expiratory connector port
- 3 Socket for breathing gas temperature sensor plug
- 4 Inspiratory connector port
- 5 Nebulizer gas supply port
- 6 Bacteria filter
- 7 Protective cover for O₂ sensors

Rear Panel



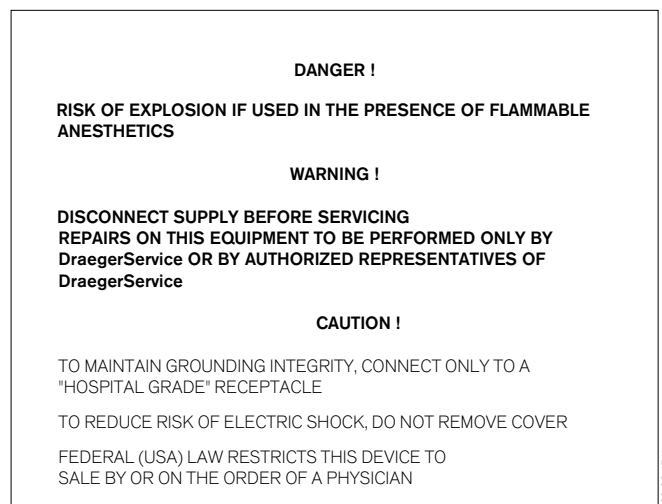
929J56810

- 1 RS232 serial interface
- 2 Nurse call socket (optional)
- 3 Power switch
- 4 Fuse for internal battery
- 5 AC input receptacle
- 6 DC inlet (external battery or on-board DC system)
- 7 Equipotential bonding connection (grounding pin)
- 8 Filter cover
- 9 ID label/rating plate
- 10 In the side panel:
connection for O₂ high pressure supply hose

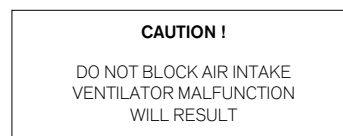
Please adjust label wording to
match what's on the ventilator

Labels

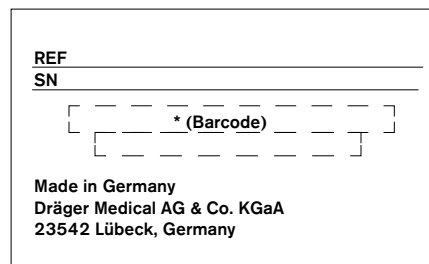
1 Main WARNING/CAUTION label



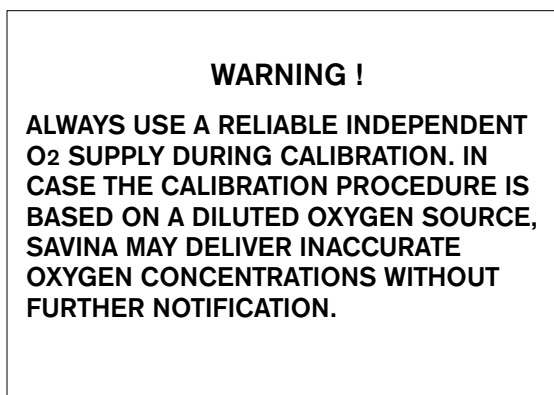
2 Air intake CAUTION label



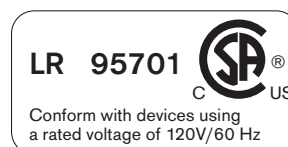
3 ID label, Dräger Medical AG & Co. KGaA, Lübeck



4 WARNING label to assure accurate O₂ calibration



5 CSA-label



Abbreviations

Abbreviation	Definition
A/C	Assist Control , Assisted Mandatory Ventilation
AutoFlow [®]	Ventilation mode extension automatically adjusting inspiratory flow to changes in lung conditions and spontaneous breathing
bpm	breath per minute , unit for ventilation/breathing rate
BTPS	Body Temperature, Pressure, Saturated Measured values based on the conditions of the patient's lungs, with body temperature 37 °C, atmospheric pressure, water-vapor saturated gas
C	Compliance
CMV	Continuous Mandatory Ventilation
CMV _{Assist}	Assisted Continuous Mandatory Ventilation
CPAP	Continuous Positive Airway Pressure Breathing with continuous positive pressure in the airways
CPPV	Continuous Positive Pressure Ventilation
ΔP _{supp.} above PEEP	Setting for pressure support above PEEP
EN 794-1	European standard for medical ventilation equipment Part 1, "Intensive Care Ventilation"
f	Frequency (Rate)
f _{Apnea}	Frequency setting for apnea ventilation
f _{tot}	Overall breathing frequency (mechanical and spontaneous)
Fail to cycle	Ventilator detects no inspiration
FiO ₂	Inspiratory O ₂ concentration
FlowAcc	Flow acceleration
FlowPeak	Flow peak
Int. PEEP	Intermittent Positive End-Expiratory Pressure = Sigh
IPPV	Intermittent Positive Pressure Ventilation
IRV	Inversed Ratio Ventilation Ventilation with inversed inspiration/expiration ratio
I : E	Ratio of Inspiration time to Expiration time
MV	Minute ventilation
MV _{leak}	Leak minute volume
MV _{spn}	Spontaneous fraction of minute ventilation
NIV	Non-invasive ventilation
O ₂	Setting for inspiratory oxygen concentration
Paw	Airway pressure

Abbreviation	Definition
P _{aw} high	Airway pressure high
PCV+ (BIPAP)	P ressure C ontrolled V entilation plus Ventilation mode for spontaneous breathing at continuous positive airway pressure with two different pressure levels
PEEP	P ositive E nd- E xpiratory P ressure
P _{insp}	Setting of the upper pressure level in PCV+
P _{max}	Maximum airway pressure
P _{mean}	Mean airway pressure
P _{peak}	Peak pressure
P _{plat}	End-inspiratory airway pressure
ΔP _{supp.}	Set value of pressure support
Plateau	An inspiratory pause
PS	Pressure support
R	Resistance
SIMV	S ynchronized I ntermittent M andatory V entilation
T	Inspiratory breathing gas temperature
T _{Disconnect}	Delay time for alarm at "Airway pressure lower alarm limit" (»Mask/NIV« mode only)
T _e	Expiratory time
T _{insp}	Setting for inspiratory time
T _{plat}	Plateau time
VT	Setting for tidal volume
VT _{Apnea}	Setting for tidal volume of apnea ventilation
V _{Te}	Expiratory tidal volume
V _{Ti}	Inspiratory tidal volume
V _{Tpat}	Leak-compensated inspiratory measured tidal volume, only in NIV mode

Symbols

Symbol	Explanation
	Switch nebulizer on / off
	Activate / deactivate oxygenation program for bronchial suction
	Start manual inspiration and hold
	Select settings page
	Configure system settings
	Display alarm limits
	Display measured values
	Switch between flow / pressure waveform
	Set screen brightness to bright / dark
	Mute audible alarm for 2 minutes
	Acknowledge alarms
	Lock ventilation parameters and ventilation mode
	Standby
	Upper alarm limit
	Lower alarm limit
	Lower / upper alarm limit
	Refer to instructions for use!
	Protection class Type B
	Protection class Type BF
	Insert flow sensor

Technical Data

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Settings 132

Performance Data 133

Measured Value Displays 134

Monitoring 136

Operating Data 137

Materials Used 139

Classifications / Standards 139

Technical Data

Environmental Conditions

During operation	
Temperature	5 to 40 °C (41 to 104 °F)
Atmospheric pressure	700 to 1060 hPa
Rel. humidity	5 to 95 %, no condensation
During storage and transit	
Temperature	−20 to 70 °C (−4 to 158 °F)
Atmospheric pressure	600 to 1200 hPa
Rel. humidity	10 to 95 %, no condensation

Settings

Ventilation modes	CMV, CMV _{Assist} SIMV, SIMV / PS PCV+, PCV+/PS CPAP/PS
Ventilation frequency	2 to 80 bpm
Inspiration time T _{insp}	0.2 to 10 s
Tidal volume V _T Accuracy ^{**}	0.05 to 2.0 L, BTPS [*] greater of ±10 % of set value or ±25 mL
Inspiratory pressure P _{insp}	0 to 99 cmH ₂ O ^{***}
O ₂ concentration Accuracy ^{****}	21 to 100 vol.% ±3 vol.% The accuracy of the inspiratory O ₂ concentration is noticeably reduced when operating Savina without O ₂ sensors.
Positive end-expiratory pressure PEEP or interm. PEEP	0 to 35 cmH ₂ O
Trigger sensitivity (may be switched off in CMV ventilation mode) Accuracy	1 to 15 L/min greater of ±8 % of set value or ±0.5 L/min
Pressure assist ΔP _{supp.}	0 to 35 cmH ₂ O (relative to PEEP)
Flow Acceleration (FlowAcc) Accuracy	5 to 200 cmH ₂ O/s ±10 % of set value

* BTPS
Body Temperature, Pressure, Saturated.
Measured values with reference to the conditions in the patient's lung,
body temperature 37 °C, ambient pressure, water vapor saturated gas.

** Valid for 25 °C ambient temperature and 50 % relative humidity.
At higher humidity levels, the flow-dependent variables are up to 8.3 % less than the values indicated.

*** (Affected are: setting for tidal volume V_T, reading for FlowPeak, alarm limit for insp. tidal volume).
1 cmH₂O = 101.97 Pa

**** Valid for 25 °C ambient temperature and 50 % relative humidity.
At higher humidity levels, the oxygen percentage of the dry gas is up to 2.5 vol.% higher than the measured value.

Performance Data

Control principle	time cycled, volume constant, pressure controlled
Intermittent PEEP frequency	2 cycles every 3 minutes
Nebulization of pharmaceutical aerosols (with O ₂ supply only)	for 30 minutes, in the inspiratory flow phase, 2 bar (29 psi), max. 10 L/min, Savina takes the nebulizer flow into account to keep the minute-ventilation constant.
Oxygenation program for bronchial suction (with O ₂ supply only)	
detection of disconnect	automatic
detection of reconnect	automatic
pre-oxygenation	max. 3 minutes with 100 vol.% O ₂
oxygenation during suction	max. 2 minutes
post-oxygenation	2 minutes with 100 vol.% O ₂
Supply system for spontaneous breathing and PS max. inspiratory flow	blower with quick-action pressure control valve 180 L/min, BTPS*
System compliance (with bacteria filter, Fisher & Paykel MR 370 humidifier, empty F&P 370 F humidifier chamber and reusable adult patient circuit, 2.3 to 2.8 m, with or without heating wire, incl. water traps)	≤ 2 mL/cmH ₂ O
System resistance	
Inspiratory resistance	≤ 1 cmH ₂ O/60 L/min
Expiratory resistance	≤ 3.7 cmH ₂ O/60 L/min
System compliance (with bacteria filter, Fisher & Paykel MR 370 humidifier, empty F&P 340 E humidifier chamber, and reusable pediatric patient circuit, 2.7 to 2.8 m, with or without heating wire, incl. water traps)	≤ 1 mL/cmH ₂ O
System resistance	
Inspiratory resistance	≤ 2 cmH ₂ O/30 L/min
Expiratory resistance	≤ 6 cmH ₂ O/30 L/min
Additional functions	
Inspiratory relief valve	opens the breathing system in case of a failure
Safety relief valve	opens the breathing system at 100 cmH ₂ O

* BTPS
Body Temperature, Pressure, Saturated.
Measured values with reference to the conditions in the patient's lung,
body temperature 37 °C, ambient pressure, water vapor saturated gas.

Measured Value Displays

Airway pressure measurement
(Resistive differential pressure transducer)

Max. airway pressure	P _{Peak}
Plateau pressure	P _{Plat}
Pos. end-exp. pressure	PEEP
Mean airway pressure	P _{Mean}
Range	0 to 99 cmH ₂ O
Resolution	1 cmH ₂ O
Accuracy	±2 cmH ₂ O

Inspiratory O₂ measurement
(maintenance-free electrochemical sensor)

Inspiratory O ₂ concentration FiO ₂	
Range	21 to 100 vol. %
Resolution	1 vol. %
Accuracy	±3 vol. %

Flow measurement
(hot-wire sensor)

Inspiratory peak flow FlowPeak	
Range	0 to 196 L/min
Resolution	1 L/min
Accuracy	greater of ±8 % of measured value or ±0.5 L/min

Minute ventilation MV	
Spontaneously breathed minute ventilation MV _{spn}	
Range	0 to 99 L/min, BTPS*
Resolution	0.1 L/min
Accuracy	greater of ±8 % of measured value or ±0.3 L/min
T _{0...90}	approx. 35 s

Leak minute volume MV _{leak}	
Based on the inspiratory minute ventilation minute	
(only in »Mask/NIV« mode	
Range	0 to 100 %
Resolution	1 %. Leakage under 10 % cannot be indicated with sufficient resolution. 0 % is displayed.
Accuracy	greater of ±18 % of measured value or ±0.3 L/min

Measured expiratory tidal volume V _{Te}	
Range	0 to 3999 mL, BTPS*
Resolution	1 mL
Accuracy	greater of ±8 % of measured value or ±10 mL

Leak-compensated inspiratory measured tidal volume VT _{pat}	
(only in »Mask/NIV« mode	
Range	0 to 3999 mL, BTPS*
Resolution	1 mL
Accuracy	greater of ±18 % of measured value or ±20 mL

* BTPS
Body Temperature, Pressure, Saturated.
Measured values with reference to the conditions in the patient's lung,
body temperature 37 °C, ambient pressure, water vapor saturated gas.

Frequency measurement

Spontaneous breathing frequency f_{spn}

Total breathing frequency f_{tot}

Range	0 to 150 /min
Resolution	1 /min
Accuracy	± 1 /min
T0...90	approx. 35 s

Inspiratory/expiratory ratio I:E

Range	0 : 150 to 150 : 1
Resolution	0.1
Accuracy	± 6 % of measured value

Inspiratory time T_{insp}

Range	0 to 15 s
Resolution	0.1 s
Accuracy	0.1 s

Plateau time T_{plat}

Range	0 to 10 s
Resolution	0.1 s
Accuracy	0.1 s

Respiratory parameters

Resistance R^*

Range	3 to 100 cmH ₂ O/L/s
Resolution	1 cmH ₂ O/L/s
Accuracy	greater of ± 2.5 cmH ₂ O/L/s or ± 20 %

Compliance C^*

Range	3 to 200 mL/cmH ₂ O
Resolution	1 mL/cmH ₂ O
Accuracy	greater of ± 2 mL/cmH ₂ O or ± 20 %

Breathing gas temperature measurement

(NTC sensor)

Range	18 to 48 °C
Resolution	1 °C
Accuracy	± 1 °C

Waveform displays

Airway pressure P_{aw} (t)	-5 to 100 cmH ₂ O
Flow (t)	-200 to 200 L/min

* The calculation of resistance and compliance is based on a linear lung model. The algorithm does not take into account any spontaneous breathing and nonlinearities of resistance and compliance. Special circumstances like very short expirations will reduce accuracy of the calculation.

Monitoring

Expiratory minute volume MV

Upper alarm limit alarm
Setting range

when MV exceeds the upper alarm limit.
41 to 2 L/min, in 0.1 L/min increments

Lower alarm limit alarm
Setting range

when MV falls below the lower alarm limit.
0.5 to 40 L/min, in 0.1 L/min increments

Airway pressure Paw

Upper alarm limit alarm
Setting range

when the "Paw high" value is exceeded.
10 to 100 cmH₂O

Lower alarm limit alarm

when the value "PEEP +5 cmH₂O" (linked to the set value of PEEP) is not exceeded for at least 0.1 s in two successive ventilator breaths.

Delay time "TDisconnect" for
"Airway pressure lower alarm limit" alarm
(only in »Mask/NIV« mode)

0 to 60 s

Insp. O₂ concentration FiO₂

Alarm at upper limit

if FiO₂ exceeds the upper alarm limit for at least 20 seconds.

Lower alarm limit alarm

if FiO₂ falls below the lower alarm limit for at least 20 seconds.

Range

both alarm limits are automatically linked to the setpoint –
below 60 Vol.%: ± 4 Vol.%
60 Vol.% and over: ± 6 Vol.%

Tachypnea monitoring

Alarm

if the overall breathing frequency alarm threshold is exceeded during spontaneous breathing.

Adjustment range

10 to 120/min

Apnea alarm time

Alarm

Adjustment range

if no breathing activity is detected.

15 to 60 s, adjustable in 1 second increments.

Insp. Tidal Volume

Alarm

Adjustment range

if the applied tidal volume V_T exceeds the alarm threshold.

0.06 to 4.0 L

Operating Data

AC line power	100 V to 240 V, 50 / 60 Hz
Current consumption at 230 V at 100 V	max. 1.3 A max. 3.4 A
Power consumption during typical* ventilation	typically 100 W, approximately
Ventilator fuses Range 100 V to 240 V Protection class	F 5 H 250 V IEC 127-2 (2x) I, Type B 
DC fuse for internal battery	Plug-in fuse 1 SA/32 V
external DC supply (from an on-board system)	min. 10 V DC. max. 36 V DC
DC supply from external batteries	12 or 24 V
Input current (DC) 12 V battery 24 V battery	typically 10 A, max. 30 A typically 5 A, max. 15 A
Total operating time if AC supply is down, with charged external battery and typical* ventilation Examples: 12 V battery 36 Ah 24 V battery 17 Ah	approx. 3 hours (e.g. with 1 lead-gel battery 12 V/36 Ah) approx. 4 hours (e.g. with 2 lead-gel batteries 12 V/17 Ah)
Total operating time if AC supply is down and no external DC supply is available (new, fully charged internal batteries)	60 minutes (±12 minutes) with typical* ventilation

External battery

Sourcing information:
Standard rechargeable lead or lead-gel batteries
can be used, e.g.

Sonnenschein	A212 / 36 A (1 or 2 batteries)
Panasonic	LCL 12 V 17P (2 batteries) LCL 12 V 33AP (1 or 2 batteries) LCL 12 V 38P (1 or 2 batteries)

CAUTION ! Do not use batteries that use
chemical systems other than lead/acid
(such as NiCd, NiMH)

Battery charging:
Savina automatically detects the voltage of the
external battery connected.

Charge current for the external battery:	12 V battery approx. 4 A 24 V battery approx. 2 A
--	--

When the external battery is fully charged, the
charging system switches to trickle charging.
Trickle charging is performed by short current
pulses.

* CMV mode, VT=700 mL, FiO2=21 %, Flow Acc=30 cmH2O/s, Tinsp=2 s, f=12 bpm, PEEP=5 cmH2O,
7 mm tube connector (R=5 cmH2O/L/s), Clung=Dräger bag 2 L (C=52 mL/cmH2O)

Technical Data

Operating Data

Charging times

Charging times indicated refer to immediate charging of the external battery after discharge. Several successive partial discharges without charging from AC may extend the necessary charging time for a full charge.

Type	lead-gel battery, maintenance-free, sealed
Minimum capacity	
12 V battery	33 Ah
24 V battery	17 Ah
Charging time	
12 V battery	<14 hours (approximately 10 hours for 80 % charge)
24 V battery	<12 hours (approximately 9 hours for 80 % charge)
Charge current	
12 V battery	3 A
24 V battery	2 A

Internal battery

Type	lead-gel batteries, maintenance-free, sealed
Charging time	<5 hours, also when charging from an external on-board DC supply (approximately 2.5 hours for 80 % charge)

Gas supply

O ₂ gauge pressure	3 bar – 10 % to 6 bar (43.5 to 87 psi)
O ₂ connection thread	DISS
Dew point	5 °C below ambient temperature
Oil content	<0.1 mg/m ³
Particles	dust free (filtered with mesh size <1 micron).

Output for pneumatic nebulizer	O ₂ , max. 2 bar (29 psi), max. 10 L/min
--------------------------------	---

Sound pressure level

(for free-field measurement over a reflecting surface)	≤45 dB (A) for typical* ventilation at 1 m (3.3 feet) distance from front of ventilator
--	---

Physical characteristics

Dimensions (W x H x D)	
Ventilator	380 x 383 x 358 mm (15.0 x 15.1 x 14.1 inches) ±2 mm (0.08")
Ventilator with mobile stand	550 x 1347 x 559 mm (21.7 x 53 x 22 inches) ±5 mm (0.2")
Weight	
Ventilator only	approx. 24 kg (53 lbs)

Interface

Digital output / input	Output and input via RS 232 C interface for MEDIBUS protocol
------------------------	--

* CMV mode, VT=700 mL, FiO₂=21 %, Flow Acc=30 cmH₂O/s, T_{insp}=2 s, f=12 bpm, PEEP=5 cmH₂O, 7 mm tube connector (R=5 cmH₂O/L/s), C_{lung}=Dräger bag 2 L (C=52 mL/cmH₂O)

Classifications / Standards

EC Classification

as per EC Directive 93/42/EEC
Appendix IX

Class IIb

UMDNS-Code

Universal Medical Device Nomenclature System –
classification for medical products

17 – 429

Electrical protection classification

Ventilator

Temperature sensor AWT01 (installed sensor)

Class I

Type BF 

Electromagnetic compatibility EMC

tested to EN 60601-1-2

Applicable standards

EN 794-1, Lung ventilators –
Part 1: Special requirements for intensive care
ventilators

EN 60601-1, Medical electrical appliances –
Part 1: General safety rules (IEC 60601-1, 1996)

EN 60601-1-2, Medical electrical appliances –
Part 1: General safety rules –
Second supplementary standard: Electromagnetic
compatibility – Requirements and testing
(IEC 60601-1-2, 1993)

RTC/DO-160D, Environmental Conditions and Test
Procedures for Airborne Equipment, Section 21:
Emissions of radio frequency energy, 29.7.1997

MIL-STD-461, Requirements for the control of
electromagnetic interference emissions and
susceptibility, RE 101, CS 114, RS 101

Materials Used

Part	Appearance	Material
Ventilation circuit (reusable)	milky, transparent	silicone rubber
Water traps	yellow, transparent	polysulphone
Y-piece with connector for temperature measurement	yellow, transparent milky, transparent	polysulphone silicone rubber
Expiratory valve housing, closure	white	polyamide
Diaphragm	whitish and grey	silicone rubber and nickel

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Theory of Operation

Ventilation Modes - Volume Controlled Ventilation	142
PCV+ (BIPAP) (Available Option)	148
Automatic Leak Compensation	149
NIV – Non-invasive Ventilation (Available Option)	150

Theory of Operation

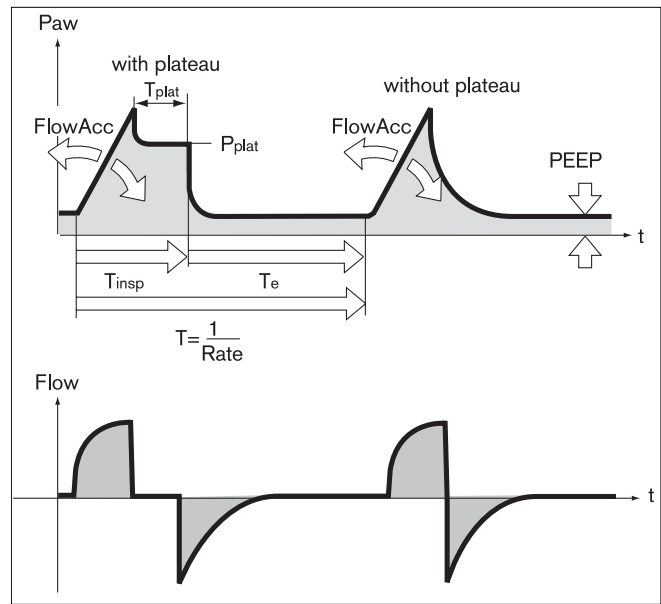
Ventilation Modes – Volume Controlled Ventilation

CMV Volume constant mandatory ventilator breaths

The ventilation pattern is defined by settings for tidal volume V_T , frequency f , inspiratory time T_{insp} , PEEP, and FlowAcc.

At the end of the flow phase, the expiratory valve remains closed until the end of inspiratory time T_{insp} . This phase, the inspiratory pause, can be identified as the plateau P_{plat} in the P_{aw} (t) waveform. The values for plateau pressure P_{plat} and plateau time T_{plat} are shown on screens »Values 1/2« and »Values 2/2«.

When the plateau is turned off, Savina switches to expiration immediately after the set tidal volume V_T has been applied. In this case the inspiratory time is not an adjustable parameter. It is rather the result of the compliance and resistance of the patient's lungs in combination with the set values of tidal volume V_T and flow acceleration. The value for T_{insp} is shown on screen »Values 2/2«. Savina establishes a minimum expiratory time of 500 ms and limits the resulting I:E ratio to a maximum of 4:1.



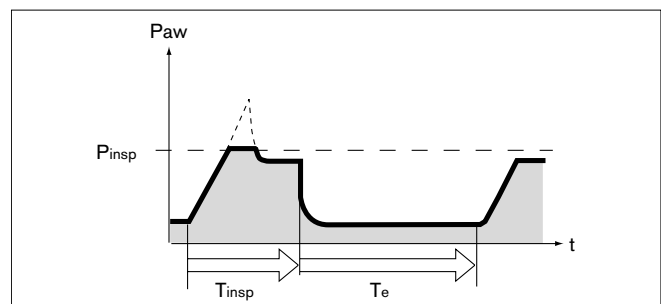
Flow acceleration

The parameter »FlowAcc« is used to influence the rise of pressure and flow. A greater value of »FlowAcc« results in a steeper (faster) rise of inspiratory pressure and flow. Flow acceleration (and inspiratory time setting) can be used for shaping the airway pressure waveform to suit an individual patient's needs.

Pressure limiting

Pressure Limited Ventilation (PLV)

Savina can limit the inspiratory peak pressure in ventilation modes CMV and CMVAssist, as well as SIMV, SIMV/PS. The »P_{insp}« ventilation parameter is used to set the limit. The value of P_{insp} remains in effect until Savina has applied the set tidal volume V_T or until the set inspiratory time has elapsed. If the set tidal volume cannot be delivered, a "Tidal Volume low"-alarm will be displayed.



CMVAssist

Assisted ventilation with continuous positive airway pressure. The mandatory ventilator breath begins when the patient reaches an inspiratory flow that matches at least the level of the set flow trigger.

Due to triggering, the actual ventilator rate may be greater than the set ventilator frequency.

Sigh (intermittent PEEP)

"Sigh", in the form of intermittent PEEP, is operative in CMV and CMVAssist modes.

The purpose of the expiratory sigh during ventilation is to open up collapsed areas of the lung, and to keep open "slow" lung compartments.

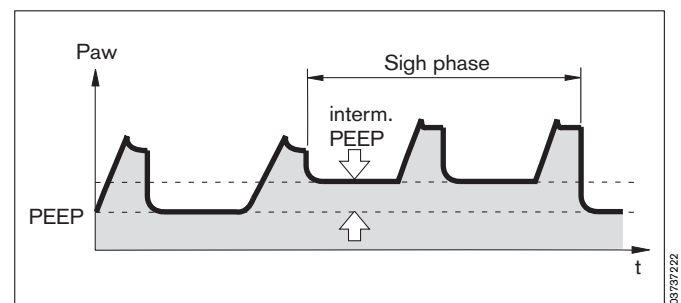
Since atelectatic alveoli have a longer time constant – also caused by obstructed bronchioli – increased airway pressure maintained over a longer period is required to open them.

Commonly, a sigh breath is achieved by simply increasing the pressure level of a ventilator breath; however, this form of sigh improves the filling of the »slow« alveoli only marginally due to the short time available.

In the Savina ventilator, the sigh operates during expiration with an intermittent PEEP. It is set as a pressure relative to PEEP (Δ sigh).

Mean airway pressure is higher, and a longer filling time can be expected.

When the sigh is activated, the end-expiratory pressure increases by the amount of the set intermittent PEEP every 3 minutes for 2 ventilator breaths.



AutoFlow® (available option)

AutoFlow can be activated in the »Settings« menu.

With AutoFlow, the inspiratory flow is automatically adjusted to changes in lung conditions (C, R) and to the spontaneous breathing demands of the patient.

Always set the alarm limit » $P_{aw} \sqrt{f}$ « as well as $V_T \sqrt{f}$ in order to set off an alarm in the event of an increase in airway pressure or tidal volume V_T with change of compliance.

Typically, the selected inspiration time T_{insp} is noticeably longer than the filling time of the lungs. Inspiratory pressure P_{insp} corresponds to the minimum value resulting from both tidal volume V_T and compliance C of the lungs.

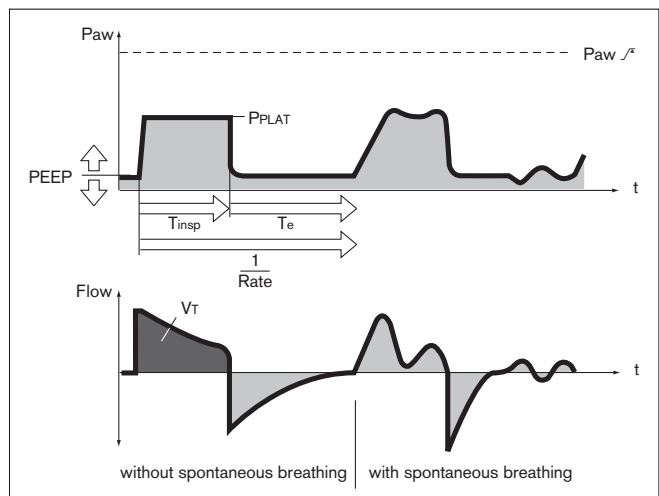
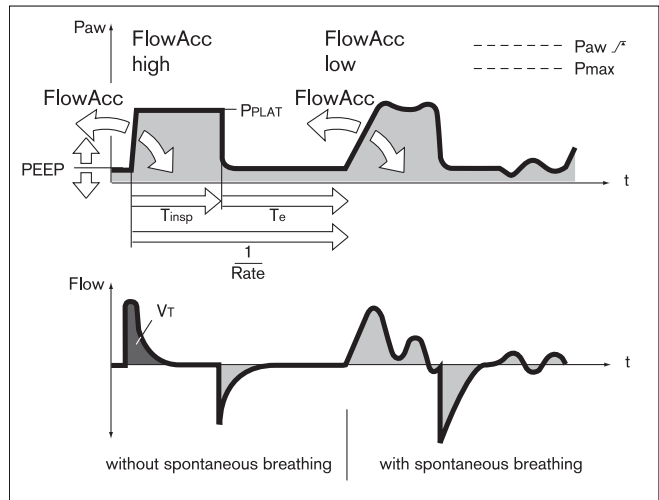
Savina automatically controls inspiratory flow so that there is no pressure peak caused by the resistances of the tube and the airways. The plateau pressure P_{plat} varies with changes in compliance C , as is normal in all constant-volume ventilator breaths. With AutoFlow, these variations occur in increments of max. 3 cmH₂O between ventilator breaths. The plateau pressure P_{plat} is automatically limited by the pressure limitation $P_{max} = P_{aw} \sqrt{f} - 5$ cmH₂O.

If the tidal volume V_T is reached (inspiratory flow = 0) before the inspiration time has elapsed, the patient can breathe in and out during the remaining inspiration time at the level of the plateau pressure P_{plat} .

If the patient breathes in or out during mandatory inspiration, the plateau pressure P_{plat} is not changed for this ventilator breath. Only inspiratory and expiratory flow are adapted to the patient's demand. The individually applied tidal volume V_T may differ from the set tidal volume V_T in specific ventilator breaths, but on average over time a constant tidal volume V_T is supplied.

An excessive increase of the tidal volume V_T can be restricted by the alarm limit » $V_{Ti} \sqrt{f}$ «. If the set alarm limit is exceeded just once, Savina displays an advisory message (!); if, however, the alarm limit is exceeded three times, Savina issues a warning message (!!!). The volume is actively limited to the value of the alarm threshold » $V_{Ti} \sqrt{f}$ « by switching pressure to PEEP level.

A set inspiratory time T_{insp} which is shorter than the filling time of the lungs can be recognized from the flow curve: the flow at the end of the inspiratory time has not yet returned to zero. It must now be decided whether the current condition of the patient permits to extend inspiratory time T_{insp} or to increase flow acceleration, in order to apply the set tidal volume V_T . A stenosis can also cause the filling time of the lungs to become longer than the set inspiration time T_{insp} .



Start-up behavior of AutoFlow

Upon switching AutoFlow on, Savina applies the set tidal volume V_T using a volume-controlled ventilator breath. The plateau pressure P_{plat} derived from this ventilator breath serves AutoFlow as a starting value for the inspiratory pressure.

Settings to suit the patient's needs

The start of mandatory inspirations can be synchronized with the patient's inspiratory effort using the flow trigger parameter. Flow trigger can only be completely turned off in CMV (CMV_{Assist} → CMV).

With ventilation parameter »FlowAcc«, the steepness of the pressure rise from PEEP level to the inspiratory pressure level can further be adapted to suit the patient's needs in SIMV and CMV.

SIMV

Synchronized Intermittent Mandatory Ventilation

Combination of mandatory ventilation and spontaneous breathing.

SIMV enables the patient to breathe spontaneously during predefined, regular intervals between mandatory ventilator breaths that ensure a minimum ventilation.

This minimum ventilation is controlled by setting two values: tidal volume (V_T) and ventilator rate. The minimum ventilation is the product of $V_T \times \text{Rate}$.

The ventilation pattern is defined by the set values of tidal volume V_T , ventilator rate, inspiratory time T_{insp} and flow acceleration FlowAcc.

To prevent a mandatory mechanical breath from being delivered during a spontaneous expiration, the flow trigger of the ventilator ensures that the mechanical breath is triggered within a "trigger window" and synchronized with the patient's spontaneous inspiratory effort.

The maximum length of the "trigger window" is 5 seconds.

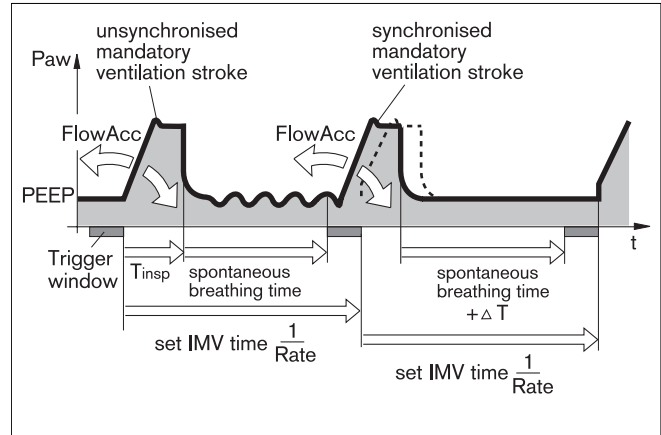
If expiratory times are less than 5 seconds, the trigger window will cover the entire time of expiration, less the first 500 ms which are reserved as a minimum expiratory time.

Synchronization of mandatory ventilator breaths by itself effectively reduces SIMV time, which would result in an undesirable increase in the effective IMV rate. Savina therefore extends the subsequent time allowed for spontaneous breathing by the missing time difference ΔT – thus preventing an increase in SIMV rate. The mandatory breathing rate f is kept constant. It is, together with tidal volume V_T , responsible for minimum ventilation.

If the inspiratory volume of the patient is considerable at the beginning of the trigger window, the ventilator reduces its subsequent mandatory ventilator breath by shortening the time for the inspiratory flow phase and overall inspiratory time. The tidal volume V_T remains constant, and over-inflation of the lungs is avoided.

During the phases of spontaneous breathing, the patient can be assisted with pressure support.

In the course of weaning a patient from artificial ventilation, ventilator rate can be progressively reduced which, in turn, will increase spontaneous breathing time, so that more and more of the required total minute volume is supplied entirely by spontaneous breathing. For this purpose, the ventilator rate may be reduced down to 2/min.



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Pressure support

Support by augmented pressure for insufficient spontaneous breathing.

The ventilator function for assisting insufficient spontaneous breathing is similar to that of an anesthetist manually assisting and monitoring a patient's spontaneous breathing by feeling the breathing bag.

The ventilator takes over part of inspiration, with the patient maintaining control of spontaneous breathing.

The CPAP system supplies the spontaneously breathing patient with breathing gas even during weak inspiratory efforts.

Pressure support is started:

- when the spontaneous inspiratory flow reaches the set value of the flow trigger
- or, at the latest
- when the spontaneously inspired volume exceeds 25 mL.

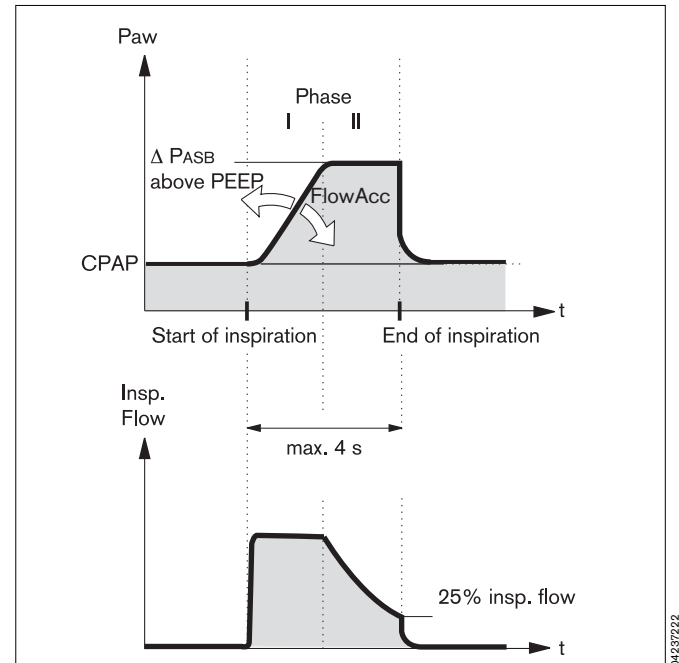
The ventilator then produces an increase in pressure up to the preselected support pressure ΔP_{supp} above PEEP, which is adjustable to the breathing requirement of the patient. The flow supply can be adjusted using »FlowAcc« to meet the individual needs of the patient.

- In case of high flow acceleration:
Savina supports the insufficient spontaneous breathing of the patient with a high peak flow.
- In case of low flow acceleration:
Savina begins gently with an even inspiratory flow.

Pressure support is terminated:

- when the inspiratory flow returns to zero during phase I, i.e. when the patient exhales or is 'fighting' the ventilator, or
- when the inspiration flow in phase II falls below 25 % of the last inspiratory flow supplied (and therefore indicates that " ΔP_{supp} above PEEP" has been reached) or
- at the latest after 4 seconds if the two other criteria have not triggered termination of the breath.
If this time criterium occurs, the advisory message **! PS > 4 s** is displayed. If this condition occurs three times in succession, Savina displays a warning message **!!! PS > 4 s** and warns of a possible leak in the patient circuit.

In »Mask/NIV« mode, the »Tinsp« key is used to set the maximum duration of pressure support breaths.



PCV+ (BIPAP) (Available Option)

**Pressure Controlled Ventilation plus
Biphasic Positive Airway Pressure**

PCV+ is a pressure controlled/time cycled ventilation mode which allows the patient to breathe spontaneously at any time. PCV+ is therefore often described as a time cycled alternation between two CPAP levels.

The time cycled change of pressure produces controlled ventilation similar to pressure controlled ventilation PCV. However, the possibility of uninhibited spontaneous breathing allows the transition from controlled breathing to independent spontaneous breathing to take place gradually over the course of weaning, without requiring any change in the ventilation mode. Both pressure level transitions (from expiratory to inspiratory pressure level, as well as from inspiratory to expiratory pressure level), are synchronized with the patient's spontaneous breathing for a good adaptation to the patient's own breathing pattern.

The overall frequency of the transitions is kept constant, even with patient synchronization, by using a fixed time trigger window.

This smooth adaptation to the patient's spontaneous breathing lowers the need for sedation, so that the patient may return to spontaneous breathing more quickly.

As in all pressure-controlled ventilation modes, the patient is not prescribed a fixed tidal volume (V_T). The tidal volume essentially results from the pressure difference between settings for PEEP and P_{insp} and the patient's lung compliance.

The display of measured expiratory tidal volume, V_{Te} , is used when setting the required difference between the two pressure levels. Any increase in this difference will cause an increase in the size of the mechanical PCV+ breath.

Changes in lung compliance and airways, as well as a patient actively 'fighting' the ventilator, can lead to changes in tidal volume. This effect is intentional in this ventilation mode.

Knowing that tidal volume, and therefore minute volume, are not constant, great care must be taken to adjust the alarm limits for minute volume adequately.

Using PCV+

As in CMV, the timing pattern is set using the basic parameters of ventilator rate f and inspiratory time T_{insp} . The lower pressure level is set with parameter PEEP, while the upper level is set with P_{insp} .

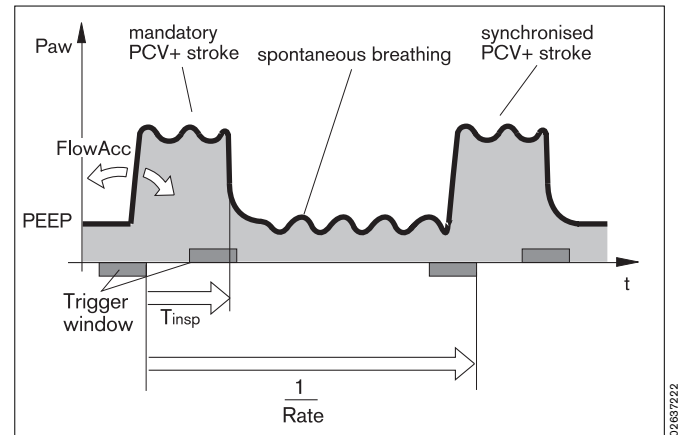
When switching from volume controlled ventilation to PCV+ mode, only the P_{insp} setting needs to be changed – while retaining the timing pattern.

The steepness of the rise from the lower to the upper pressure level is controlled by the setting of »FlowAcc«.

During the lower pressure level phase, spontaneous breathing may be augmented by pressure support.

The steepness of the rise to pressure support pressure ΔP_{supp} above PEEP is also controlled by the setting of flow acceleration.

Weaning a patient from controlled ventilation to fully spontaneous breathing is achieved by gradually reducing inspiratory pressure P_{insp} and/or ventilator rate f .



Automatic Leak Compensation

The algorithm of the Savina Automatic Leak Compensation determines per breath the difference between the delivered flow on the inspiratory side and the measured flow on the expiratory side. This difference provides a measure of the amount of leakage, which is used to calculate 100 times per second the actual leakage flow based on the actual inspiratory or expiratory flow. This calculated dynamic leakage flow is used to correct in real time (100 times per second) the inspiratory flow and the flow values for trigger detection.

Automatic leakage compensation for trigger detection

In order to synchronize with the patient's efforts to breathe in and out, Savina detects volumes and flows values generated by the patient. In order to optimize synchronisation, the measured flow values are automatically corrected to take into account leak flow, up to a maximum of 10 L/min.

The leakage compensation continuously adapts (breath by breath) to changing leakages. In case the changes in leakage are very large or occur in a short amount of time, e.g. the patient's face mask moves and creates a sudden very large leak, such large change may lead to temporary over or under compensation, reduced trigger sensitivity or even auto-triggering. The algorithm will recalculate the new leakage and "recover" from this temporary state within 1-2 breaths.

Leak monitoring

If Savina detects a major leak in the system while in »Tube« mode, the advisory message **! Leakage** appears. In this case, tube and patient circuit should be checked for tight connections.

NIV – Non-invasive Ventilation (Available Option)

With the NIV option, Savina offers an application mode optimized for non-invasive ventilation using a nose or face mask. Greater leakage generally occurs with non-invasive ventilation than with ventilation via a tube. For this reason, automatic leakage compensation for trigger detection, alarms and monitoring are adjusted to these special conditions when operating in »Mask/NIV« mode. Additionally, Savina automatically compensates for volume lost due to leaks in volume-controlled ventilation modes.

Automatic leakage compensation for trigger detection

As in invasive ventilation with Savina, automatic leak compensation is performed with respect to the trigger criteria in »Mask/NIV« mode. For trigger detection purposes, Savina takes into account leaks of up to 25 L/min.

In addition the corrected flow values are used for the termination criteria of pressure supported inspirations.

Alarms

During non-invasive ventilation in »Mask/NIV« mode, some alarm limits are not needed in certain circumstances or cannot be monitored due to large artifacts. For example, in the case of very big leaks it is often not possible to measure any expiratory minute volume. If this alarm were not switched off, the ventilator would constantly generate alarms. For this reason, the following alarms can be deactivated in »Mask/NIV« mode:

- Minute volume low
- Tidal volume high
- Apnea detection.

Non-invasive ventilation with the alarms switched off is only permissible if the patient's safety is not put at risk.

The operator of the ventilator must always assume full responsibility for proper ventilation and patient safety in all situations. Please refer to "Monitoring in the »Mask/NIV« mode" on page 73.

The **!!! Airway pressure low** alarm can be delayed for up to 60 seconds. This is done by setting a delay time $T_{\text{Disconnect}}$ from 0 to 60 seconds on an additional screen page

»Alarms 2/2«. For example, with a setting of 10 seconds the patient can remove the mask for up to 10 seconds before Savina activates an **!!! Airway pressure low** alarm. Because leaks are normal in non-invasive ventilation, the messages **! Leakage**, **! PS >4s** and **!!! PS >4s** are not displayed in this mode.

Monitoring

Savina provides an additional »Values« screen page in »Mask/NIV« mode. Among other things, this screen shows leak minute volume MV_{leak} as a percentage of the measured minute ventilation. The tidal volume $V_{T\text{pat}}$ indicates the volume actually reaching the patient. $V_{T\text{pat}}$ is the delivered tidal volume less the volume lost to leaks during inspiration.

After extreme changes in leakage the values for leak minute volume MV_{leak} and patient tidal volume VT_{pat} may temporarily deviate.

Automatic volume compensation

If volume-controlled ventilation modes (CMV, SIMV) are applied in »Mask/NIV« mode, Savina increases the applied tidal volume VT by the amount lost to leaks during inspiration. If a tidal volume VT of 500 mL has been set and 50 mL are lost during inspiration, Savina will automatically deliver 550 mL. Because unlimited leak compensation is not advisable, Savina only compensates for leaks of up to 100 % of the set tidal volume.

Extreme changes in leakage may lead to temporary deviations in patient tidal volume from set tidal volume.

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Ordering Information

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Ordering Information

Name/Description	Order No.
Basic ventilator	
Savina	84 13 600
Options	
Option AutoFlow®	84 14 130
Option PCV+	84 14 131
Option NIV	84 14 072
Nurse call system	84 13 631
Plug for the connection of nurse call system	18 46 248
90° O ₂ connector	84 13 641
Set of side rails (for mounting accessories)	84 14 358
Humidifier accessories	
Mounting brackets (for Fisher Paykel MR 370)	84 11 074
Special accessories	
Mobile Cart SavinaMobil	84 14 335
Adult size test lung	84 03 201
Column extension kit	84 13 962
MEDIBUS cable	83 06 488
DC battery cable S	84 14 092
ext. lead acid gel battery 12 V / 17Ah (2 required)	18 43 303
DC cable S, for external DC supply on board	84 14 048
Temperature sensor el.	84 05 371
Consumables	
O ₂ -Sensor (Oxytrace VE)	MX 01 049
Flow-Sensor Spirolog (pack of 5)	84 03 735
Replacement parts	
Dust filter kit	84 14 057
Microfilter	67 37 545
Expiratory valve	84 13 660
Water trap	84 04 985

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These Instructions for Use apply only to
Savina
with Serial No.:

If no Serial No. has been filled in by
Draeger, these Instructions for Use are
provided for general information only and
are not intended for use with any specific
machine or device.

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